MEDICAL BIOLOGY

PRACTICAL BOOK
FOR THE FIRST-YEAR STUDENTS STUDYING IN THE SPECIALTY «DENTISTRY»

Minsk BSMU 2022

МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ
БЕЛОРУССКИЙ ГОСУДАРСТВЕННЫЙ МЕДИЦИНСКИЙ УНИВЕРСИТЕТ
КАФЕДРА БИОЛОГИИ

МЕДИЦИНСКАЯ БИОЛОГИЯ
MEDICAL BIOLOGY

Практикум
для студентов, обучающихся на английском языке по специальности «Стоматология»

Минск БГМУ 2022

УДК 57:61(076.5)(075.8)-054.6
ББК 28.0я73
М42

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А в т о р ы: В. В. Григорович, В. В. Давыдов, Ю. И. Корбут, Е. А. Черноус, В. Э. Бутвиловский

Р е ц е н з е н т ы: канд. мед. наук, доц. О. Н. Ринейская; каф. общей химии

М42 **Медицинская** биология = Medical Biology : практикум для студентов, обучающихся на английском языке по специальности «Стоматология» / В. В. Григорович [и др.]. – Минск : БГМУ, 2022. – 68 с.

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Предназначен для студентов 1-го курса, обучающихся по специальности «Стоматология» на английском языке.

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MEDICAL BIOLOGY

Практикум для студентов,
обучающихся на английском языке по специальности «Стоматология»

На английском языке

Ответственный за выпуск В. В. Давыдов
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PLAN OF THE COURSE
1st semester

Name _____ Group_____

Week number	Topic
1.	Medical biology and its role in medical education. Subject, tasks, and methods of cytology
2.	Structural and functional organization of the cell
3.	Structural organization of the genome
4.	Cell cycle
5.	The flow of genetic information in the cell
6.	Regulation of gene expression
7.	Genomics. Techniques of molecular genetics
8.	Genetic engineering
9.	Basic laws of inheritance
10.	Genetic linkage. Genetics of sex
11.	Variation. Mutagenesis. Carcinogenesis
12.	Population genetics
13.	Human genetics
14.	**COLLOQUIUM**
15.	Reproduction of living matter
16.	Fundamentals of ontogenesis
17.	General parasitology
18.	Parasites of human I
19.	Parasites of human II

CRITERIA FOR ACADEMIC PROGRESS ASSESSMENT OF STUDENTS IN THE BELARUSIAN STATE MEDICAL UNIVERSITY

The decree of the **Ministry of education of the Republic of Belarus** № 53 from 29.05.2012 «Rules for attestation of students, cadets, listeners for mastering the content of educational programs of higher education»

10 (ten), passed:

comprehended, profound and full knowledge of the material of all the sections of the educational program and good knowledge of main issues beyond the educational program;

accurate usage of scientific terminology (including terms in foreign languages), competent, logically correct presentation of answers to questions, ability to generalize and make logical and accurate conclusions;

mastery skills of work with tools and instruments necessary for the discipline, the ability to efficiently use them for setting objectives and solving scientific and professional cases;

the remarkable ability of individual creative solutions to problems in unconventional situations;

a full and profound comprehension of information from basic and recommended additional literature in the discipline;

ability to orient in theories, concepts, and issues of the studied discipline and analytically estimate them;

creative individual work in practical and laboratory classes, active and creative participation in group discussions, and a high cultural level of solutions to questions.

9 (nine), passed:

comprehended, profound and full knowledge of the material of all the sections of the educational program;

accurate usage of scientific terminology (including terms in foreign languages), competent, logically correct presentation of answers to questions;

skills of work with tools and instruments necessary for the discipline, ability to use them for setting objectives and solving scientific and professional cases;

the ability for individual creative solutions to problems in unconventional situations of the discipline;

full comprehension of information from basic and recommended additional literature in the discipline;

ability to orient in theories, concepts, and issues of the studied discipline and analytically estimate them; regular active individual work in practical and laboratory classes, active and creative participation in group discussions, and a high cultural level of solutions to questions.

8 (eight), passed:

comprehended, profound and full knowledge of the material of all the sections of the educational program;

usage of scientific terminology (including terms in foreign languages), logically correct presentation of answers to questions;

skills of work with tools and instruments necessary for the discipline, ability to use them for solving scientific and professional cases;

the ability of the individual solution of problems in the educational discipline;

comprehension of information from basic and recommended additional literature in the discipline;

ability to orient in theories, concepts, and issues of the studied discipline and analytically estimate them;

active individual work in practical and laboratory classes, regular and active participation in group discussions, and a high cultural level of solutions to questions.

7 (seven), passed:

comprehended, profound and full knowledge of the material of all the sections of the educational program;

usage of scientific terminology (including terms in foreign languages), logically correct presentation of answers to questions;

skills of work with tools and instruments necessary for the discipline, ability to use them for solving scientific and professional cases;

the ability for the individual solution of problems in the educational discipline using typical methods;

comprehension of information from basic and recommended additional literature in the discipline;

ability to orient in theories, concepts and issues of the studied discipline and analytically estimate them;

individual work in practical and laboratory classes, participation in group discussions, and a high cultural level of solutions to questions.

6 (six), passed:

full knowledge of the material of all the sections of the educational program;

usage of necessary scientific terminology, logically correct presentation of answers to questions;

skills of work with tools and instruments necessary for the discipline, ability to use them for solving scientific and professional cases;

the ability for the individual solution of problems in the educational discipline using typical methods;

comprehension of information from basic literature in the discipline;

ability to orient in basic theories, concepts and issues of the studied discipline and analytically estimate them;

active individual work in practical and laboratory classes, periodic participation in group discussions, and a high cultural level of solutions to questions.

5 (five), passed:

enough knowledge in the material of the educational program;

usage of necessary scientific terminology, logically correct presentation of answers to questions;

skills of work with tools and instruments necessary for the discipline, ability to use them for solving scientific and professional cases;

the ability for the individual solution of problems in the educational discipline using typical methods;

comprehension of information from basic literature in the discipline;

ability to orient in basic theories, concepts, and issues of the studied discipline and analytically estimate them;

active individual work in practical and laboratory classes, partial participation in group discussions, enough cultural level of solutions to questions.

4 (four), passed:

enough knowledge in the material of educational program required for higher education;

comprehension of information from basic literature in the discipline;

usage of necessary scientific terminology, logically correct presentation of answers to questions, ability to make conclusions without considerable mistakes;

skills of work with tools and instruments necessary for the discipline, ability to use them for solving typical professional cases;

ability to solve standard cases under the commands of a lecturer;

ability to orient in basic theories, concepts, and issues of the studied discipline and analytically estimate them;

work at practical and laboratory classes under the commands of a lecturer, the acceptable cultural level of solutions to questions.

3 (three), not passed:

not enough knowledge in the material of educational programs required for higher education;

comprehension of some information from basic literature in the discipline;

usage of scientific terminology, presentation of answers to questions with considerable mistakes;

not enough skills to work with tools and instruments necessary for the discipline, incapacity to use them for solving typical professional cases;

incapacity to orient in basic theories, concepts, and issues of the studied discipline and analytically estimate them;

passiveness in practical and laboratory classes, low cultural level of solutions to questions.

2 (two), not passed:

very low knowledge of the material of educational programs required for higher education;

knowledge of some basic literature in the discipline;

inability to use scientific terminology, presentation of answers to with serious mistakes;

passiveness in practical and laboratory classes, low cultural level of solutions to questions.

1 (one), not passed:

absence of knowledge in the material of educational program required for higher education, refuse to answer, unjustified absence.

Class #1. Topic: **MEDICAL BIOLOGY AND ITS ROLE IN MEDICAL EDUCATION. SUBJECT, TASKS, AND METHODS OF CYTOLOGY**

CONTENTS OF THE TOPIC

1. The nature of life, and the role of proteins and nucleic acids in the organization of living systems.
2. Organization levels of living matter.
3. The cell theory.
4. Prokaryotes and eukaryotes.
5. Human as a biological and social being.
6. The role of biology in medical education.
7. Subject, objectives, and methods of cytology (light, electron, and fluorescent microscopy, histochemistry and immunohistochemistry, differential centrifugation, autoradiography, morphometry, etc.).
8. The method of light microscopy. The structure of a light microscope. The rules of work with a microscope.

GLOSSARY

1. **Life –**
2. **Biopolymer –**
3. **Bacteriophage (phage) –**
4. **Virion –**
5. **Capsid –**
6. **Differential centrifugation –**
7. **Autoradiography –**
8. **Cell culture –**
9. **Histochemistry –**
10. **Fluorescent dye –**
11. **Focal distance –**
12. **Resolving power of a microscope –**
13. **Eukaryotes –**
14. **Prokaryotes –**

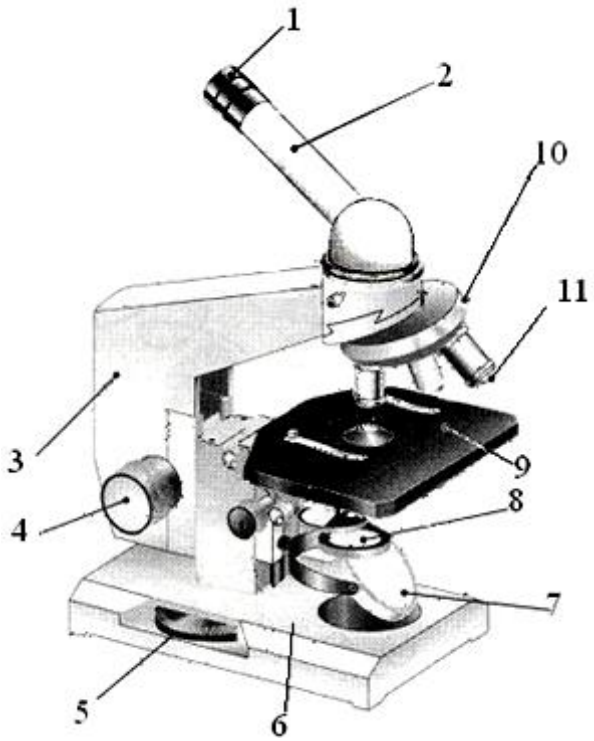

Fig. 1. The microscope «BIOLAM»:

1 – ocular lens,
2 – draw tube,
3 – arm,
4 – coarse adjustment knob,
5 – fine adjustment knob,
6 – base,
7 – mirror,
8 – condenser, diaphragm, and lens filter,
9 – stage,
10 – revolving nosepiece,
11 – objective lens

Task 1. Label the pictures.

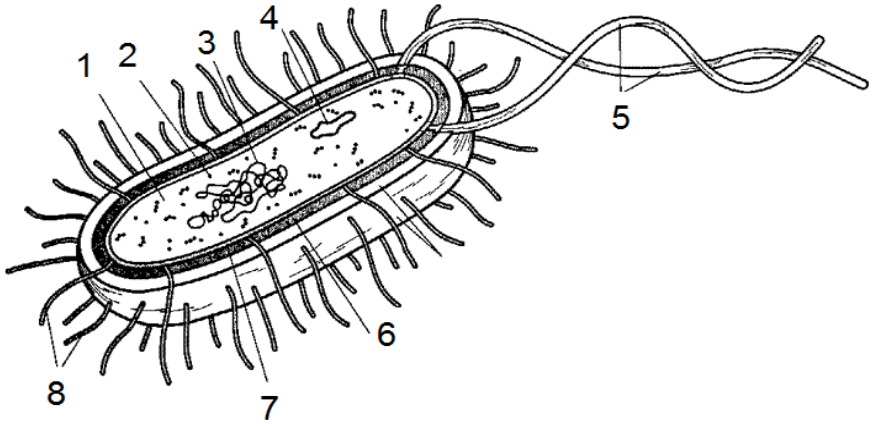

Fig. 2. Diagram of bacterium:

1 –

2 –

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6 –

7 –

8 –

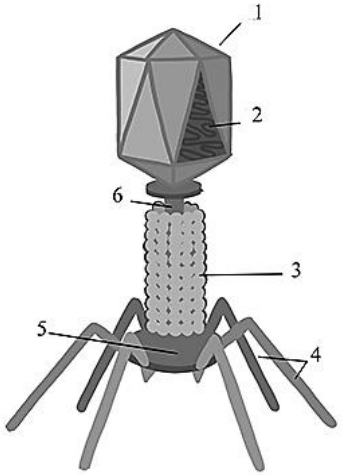


Fig. 3. Diagram of bacteriophage:

1 –
2 –
3 –
4 –
5 –
6 –

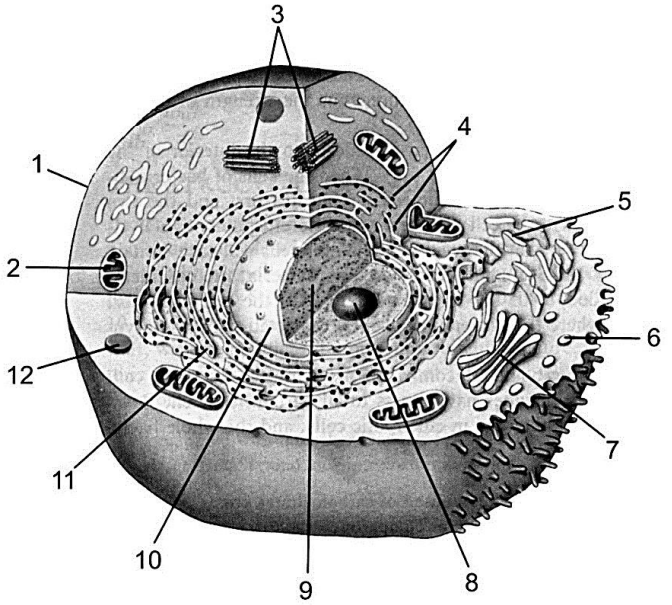
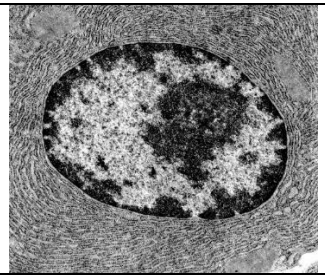


Fig. 4. Diagram of animal cell:

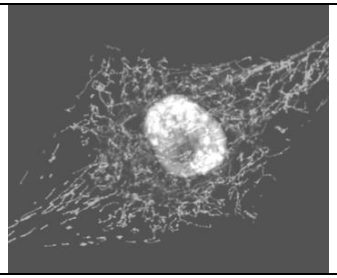
1 –
2 –
3 –
4 –
5 –
6 –
7 –
8 –
9 –
10 –
11 –
12 –

Task 2. Find the type of microscopy corresponding to each photograph.

A – Common light microscopy;
B – Fluorescent microscopy;
C – Transmission electron microscopy (TEM);
D – Scanning electron microscopy (SEM).

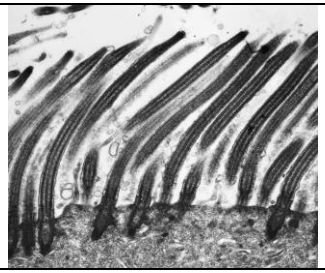


1. Nucleus



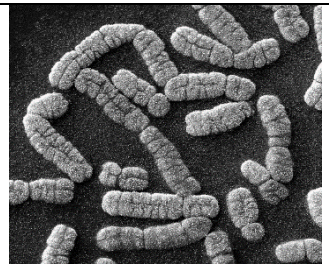
2. Nucleus and mitochondria

3. Cilia



4. Cilia

5. Anaphase



6. Chromosomes

1	2	3	4	5	6

Task 3. Find the description corresponding to the techniques.

Technique	Description
1. Light microscopy	A – removal of cell organelles and their transplantation to other cells
2. Transmission electron microscopy	B – tracking of chemical compounds in the metabolic pathways of the cell
3. Differential centrifugation	C – separation of cellular components by a centrifuge
4. Histochemistry and immunohistochemistry	D – obtaining the cell image based on the usage of visible light rays
5. X-ray crystallography	E – assessment of the chemical composition of cells and chemical reactions occurring in them
6. Cell culture	F – locating cell macromolecules using specific dyes or antibodies bound with dyes
7. Cell microsurgery	G – determination of spatial arrangement and physical properties of atoms in biological molecules
8. Scanning electron microscopy	H – analysis of biological objects stained with the dyes which fluoresce when exposed to light
9. Biochemical methods	I – growing cells of multicellular organisms on nutrient media under sterile conditions
10. Isotopic labeling	J – obtaining the images of the cell components based on the usage of electrons as a source of illumination
11. Fluorescent microscopy	K – obtaining a tridimensional image of the surface of a biological object

1	2	3	4	5	6	7	8	9	10	11

Task 4. Fill in the table comparing prokaryotes and eukaryotes. Explain the difference or write «present» / «absent».

Characteristics	Prokaryotes	Eukaryotes
Organisms		
Nucleus and organelles		
Cytoplasm		
Ribosomes		
Plasma membrane		
Membrane-bound organelles		
Cytoskeleton		
Tissues		
Common sizes		
Metabolism		
Organization of DNA		
Ploidy		
Transcription occurs in …		
Capability of phagocytosis		
Types of cell division		
Sexual reproduction		

Teacher's signature
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Class #2. Topic: **STRUCTURAL AND FUNCTIONAL ORGANIZATION OF THE CELL**

CONTENTS OF THE TOPIC

1. The structure of the plasma membrane.
2. Transport across the membrane: passive transport (simple diffusion, facilitated diffusion, osmosis), active transport, endocytosis, exocytosis.
3. Cytosol. Cytoskeleton: microtubules, intermediate filaments, microfilaments.
4. Intracellular transport of substances.
5. Assimilation. Ribosomes.
6. Endomembrane system (nuclear envelope, endoplasmic reticulum, Golgi body, lysosomes, peroxisomes, endosomes, vesicles).
7. Dissimilation. Mitochondria.
8. Lysosomal and peroxisomal disorders.

GLOSSARY

1. **Antiport –**
2. **Anabolism –**
3. **Glycolysis –**
4. **Concentration gradient –**
5. **Dictyosome –**
6. **Dynein –**
7. **Osmosis –**
8. **Peptidoglycan –**
9. **Pili –**
10. **Plasma membrane –**
11. **Simple diffusion –**
12. **Cytosol –**
13. **Endocytosis –**

Task 1. Label the diagrams.

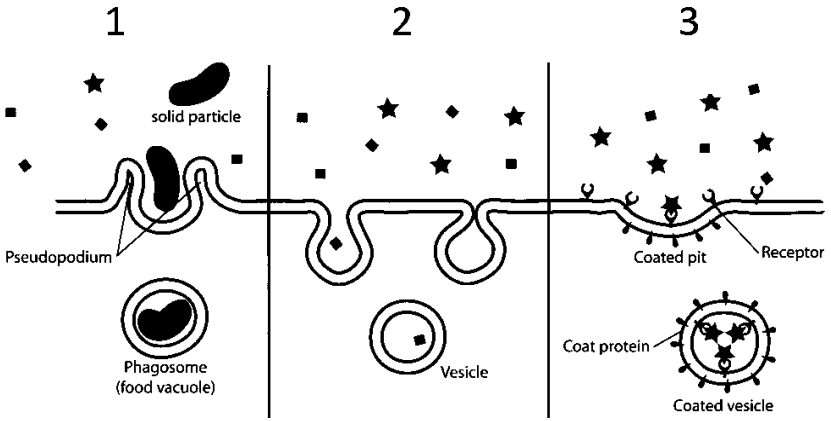


Fig. 1. Bulk transport across the cell membrane:

1 –
2 –
3 –

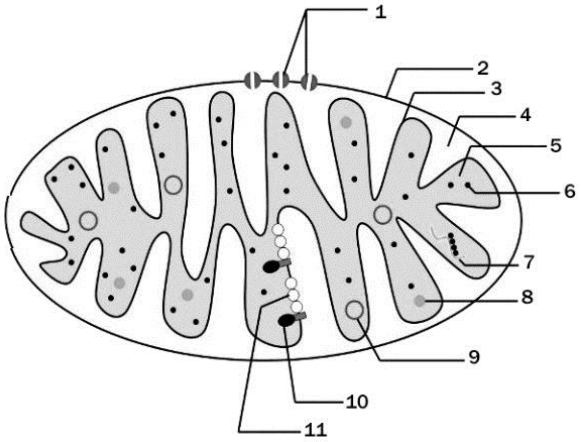


Fig. 2. Mitochondrion:

1 –
2 –
3 –
4 –
5 –
6 –
7 –
8 –
9 –
10 –
11 –

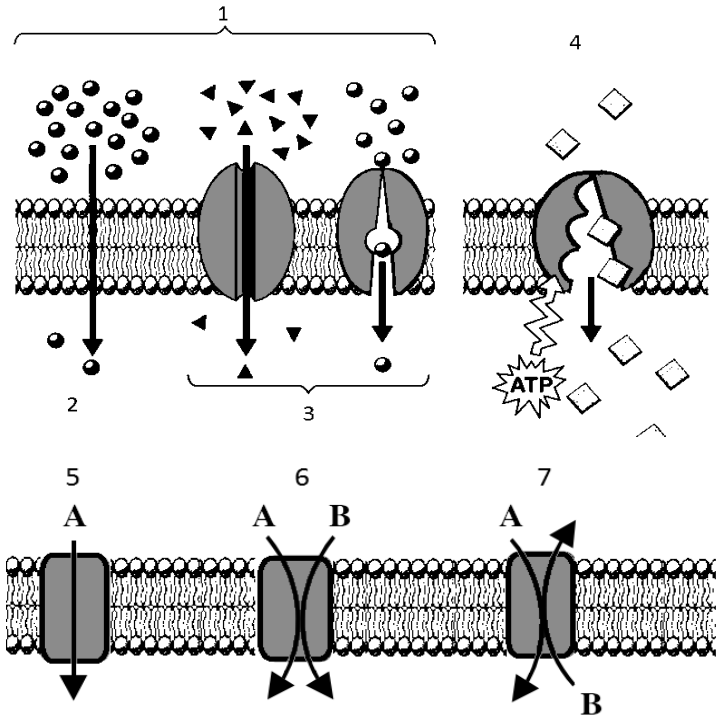


Fig. 3. Transport across the membrane:

1 –
2 –
3 –
4 –
5 –
6 –
7 –

Task 2. Label the TEMs of different organelles.

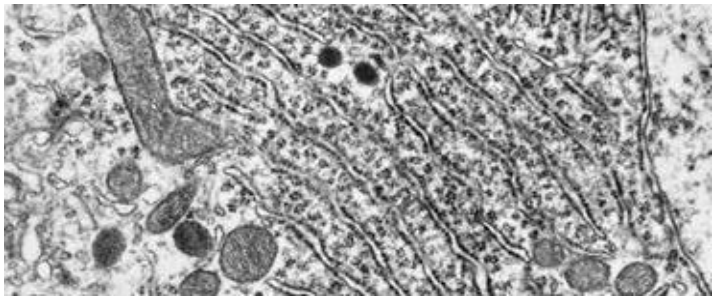


Fig. 4. Rough ER in the cells of the cerebellar cortex:
1 – membrane, 2 – channel, 3 – ribosomes

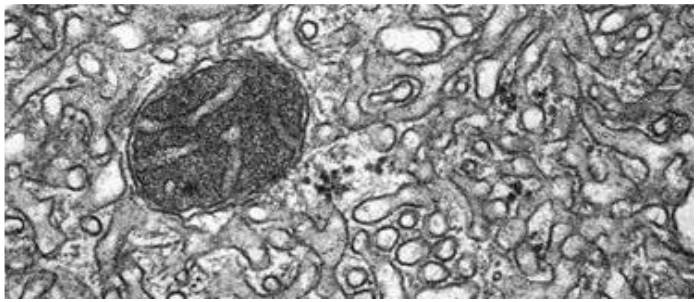


Fig. 5. Smooth ER in the cells of adrenal cortex:
1 – membrane, 2 – channel

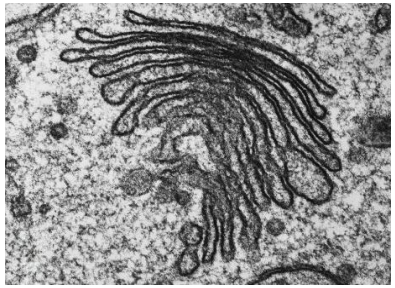


Fig. 6. Golgi apparatus:
1 – membrane, 2 – channel, 3 – cisterna, 4 – lysosome, 5 – vesicle

Fig. 7. Mitochondrion:
1 – outer membrane, 2 – inner membrane, 3 – matrix,
4 – cristae, 5 – ribosomes

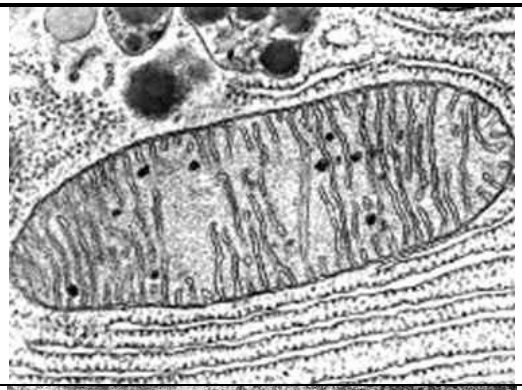


Fig. 8. Lysosomes in hepatic cells:
1 – mitochondrion,
2 – lysosome,
3 – cell membrane

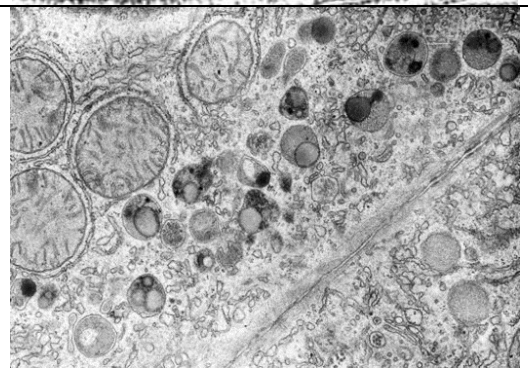
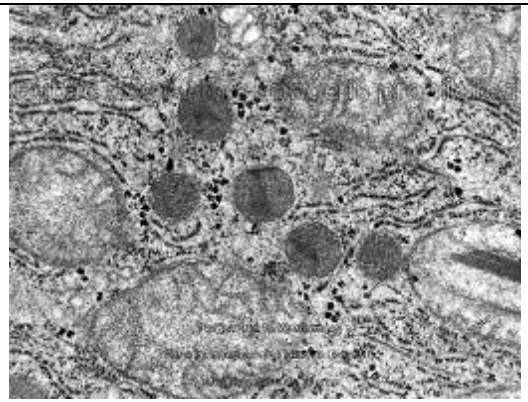


Fig. 9. Peroxisomes:
1 – mitochondrion,
2 – peroxisome,
3 – crystalized core of peroxisome,
4 – ER,
5 – ribosomes



Task 3. Label the diagram of plasma membrane.

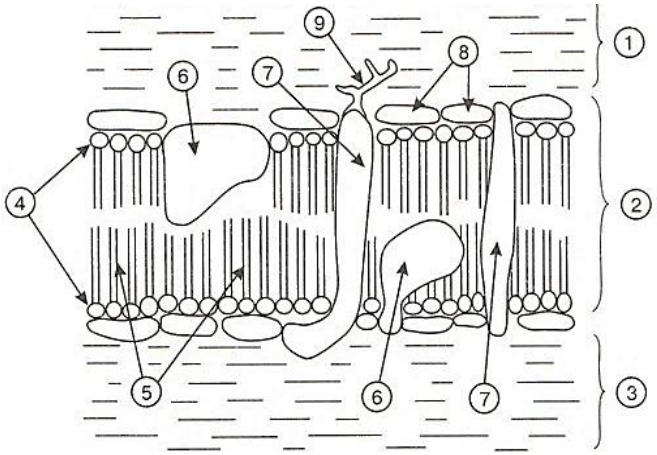


Fig. 10. The membrane of an animal cell:

1 –
2 –
3 –
4 –
5 –
6 –
7 –
8 –
9 –

Task 4. Answer the questions:

Question #1. Do mitochondria take part in protein synthesis?

Question #2. Adults do not grow. Do they need protein in food, or can it be substituted with equal calories of lipids and carbohydrates?

Question #3. What properties of plasma membrane explain its capability of endocytosis?

Question #4. How sodium-potassium pump works?

Question #5. In case of storage diseases, cells accumulate some molecules, which would be digested in normal cells. The function of what organelle is missing in case of these diseases?

Task 5. Solve the problem.

Problem #1 Leg muscles of a man spend approximately 24 kJ/min running. What is the mass of glucose required for 20 min of run? Muscles can produce 30 ATP from 1 glucose. The cell receives 30.5 kJ of energy when hydrolyzes 1 mol of ATP to ADP. The molar mass of glucose is 180 g/mol.

Teacher's signature
"___"_____20___

Class #3. Topic: **STRUCTURAL ORGANIZATION OF THE GENOME**

CONTENTS OF THE TOPIC

1. Evolution of the gene concept.
2. Evidence that DNA is the genetic material.
3. Structure and functions of DNA.
4. Genetic material of viruses and bacteria.
5. The structure and functions of the cell nucleus.
6. Gene, chromosome, and genome levels of eukaryotic genetic material.
7. DNA condensation. Remodeling of chromatin.
8. The structure of metaphase chromosomes. Euchromatin and heterochromatin. Types of chromosomes. Rules of chromosomes.
9. Karyotype and idiogram. Methods for studying the human karyotype. Classifications of human chromosomes.
10. Cytoplasmic inheritance.

GLOSSARY

1. Genome –

2. Karyotype –

3. Lamins –

4. Nucleoid –

5. Nucleotide –

6. Chromatin remodeling –

7. Nuclear localization signal –

8. Nuclear speckles –

9. Telomeres –

10. Transduction –

11. Centromere index (CI) –

12. Nucleolar organizer region –

13. Nucleosome –

14. Plasmagenes –

Task 1. Label the pictures.

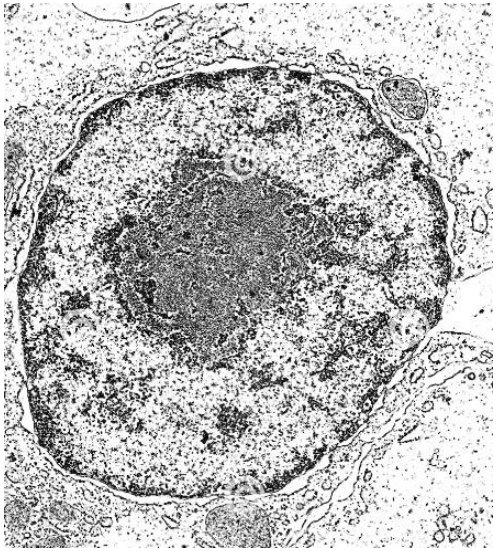


Fig. 1. TEM of the nucleus:
1 – outer membrane,
2 – inner membrane,
3 – intermembrane space,
4 – pore,
5 – karyoplasm,
6 – chromatin,
7 – nucleolus

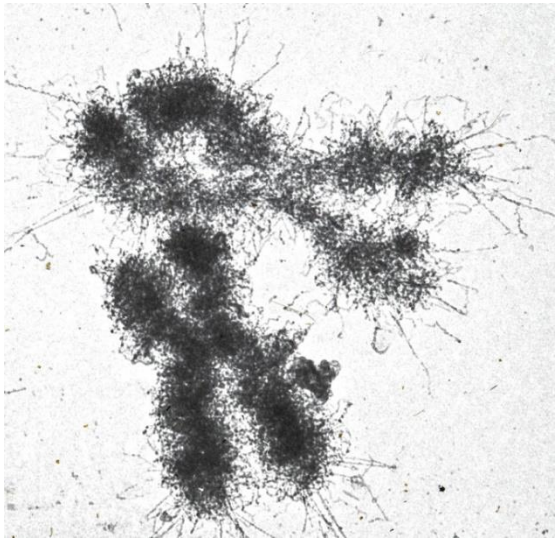


Fig. 2. TEM of human chromosomes:
1 – arm,
2 – centromere,
3 – chromatid,
4 – telomere

Task 2. Analyze the karyotype of the human and fill in the table.

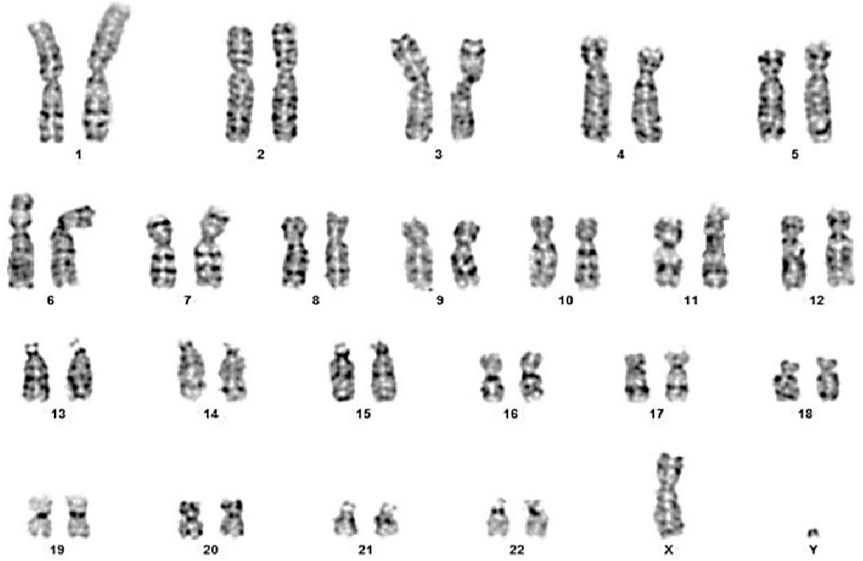


Fig. 3. Human karyotype

Groups	CI	Morphology of chromosomes
A (1-3)		
B (4-5)		
C (6-12, X)		
D (13-15)		
E (16-18)		
F (19-20)		
G (21-22, Y)		

Task 3. Solve the problems.

Problem #1. Write the complementary strands for the following ones:

a. CTGATCTGTATCAACTA

b. 3'ACTGATCTGTATCAACT5'

c. 5'GTACTAGCTAGCTAGCTAGCCAT3'

Problem #2. In a DNA molecule, cytosine is 18%. What is the percentage of other nucleotides in this DNA?

Problem #3. If a DNA molecule has 56% of GC pairs, what would be the percentage of A, G, C, and T, respectively?

Problem #4. 950 cytosines make up 20% of the total number of bases in DNA. How many adenine, thymine, and guanine are contained in the DNA fragment?

Problem #5. Adenine makes 16%, guanine – 28%, and thymine – 34% of a DNA strand. Determine the percentage of pyrimidine bases in the complementary strand.

Problem #6. A strand of DNA fragment contains 1200 bases. 25% is adenine, 10% is thymine, and 30% is guanine. What percent would be guanine in the complementary strand?

Problem #7. A DNA fragment has the following sequence in one of its two strands: GAATCAGTAAGTAT. What is the percentage of each base type in this DNA fragment? What is the length of this DNA fragment? What is the (A+T)/(G+C) ratio in that DNA fragment?

Problem #8: DNA was isolated from a bacteriophage. The bases of its genome are A – 25%, T – 33%, G – 24%, and C – 18%. How can this result be explained?

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Class #4. Topic: **CELL CYCLE**

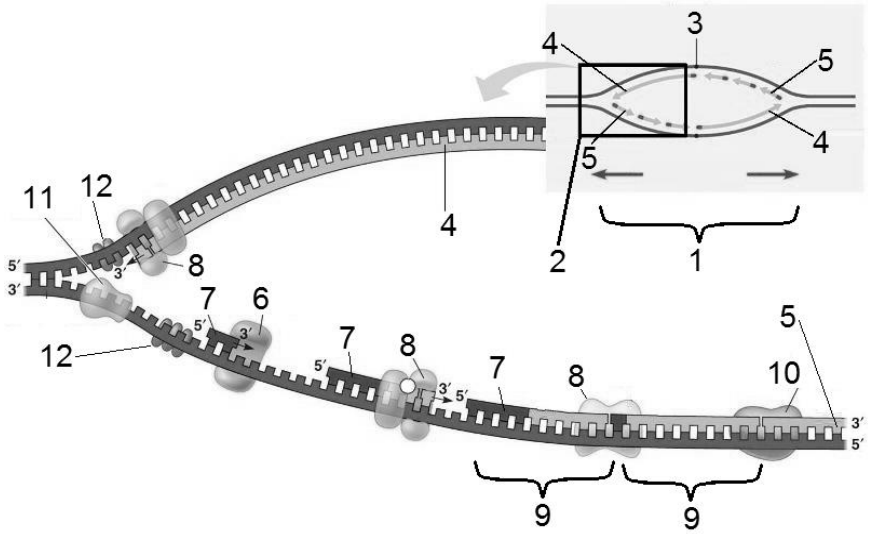
CONTENTS OF THE TOPIC

1. Cell cycle. Interphase.
2. Semi-conservative mechanism of DNA replication. Replicon.
3. Cell cycle regulators (cyclins and cyclin-dependent kinases).
4. Types of cell division: mitosis, amitosis, endomitosis. Binary division of bacteria.
5. Mitosis: characteristics of phases, distribution of genetic material, biological significance.
6. Meiosis as a type of mitosis: characteristic of phases, distribution of genetic material, biological significance.
7. Cell proliferation and cell death. Necrosis and apoptosis. Caspases.

GLOSSARY

1. **Apoptosis –**
2. **Bivalent –**
3. **Caspases –**
4. **Kinetochore –**
5. **Cohesins –**
6. **Crossing-over –**
7. **Hayflick's limit –**
8. **Necrosis –**
9. **Primase –**
10. **Replisome –**
11. **Synaptonemal complex –**
12. **Topoisomerase –**
13. **Origin of replication –**
14. **Okazaki fragment –**
15. **Chiasmata –**
16. **Cyclins –**

Task 1. Write the labels for the diagram of the replication fork.



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Task 2. Fill in the table. Write the functions of the enzymes taking part in DNA replication.

1. DNA-polymerase	
2. Primase	
3. Helicase	
4. Topoisomer-ase	
5. Ligase	

Task 3. Write the contents of genetic material in the cell at different periods of interphase, mitosis, and meiosis (for example 1n1chr1c, $1n_{biv}$4chr4c, etc.).

Interphase	Mitosis	Meiosis I	Meiosis II
G_1:	A. Prophase:	A. Prophase: **1.** Leptotene: **2.** Zygotene: **3.** Pachytene: **4.** Diplotene: **5.** Diakinesis:	A. Prophase:
S:	B. Metaphase:		B. Metaphase:
G_2:	C. Anaphase:		C. Anaphase:
	D. Telophase:		D. Telophase:
		B. Metaphase:	
		C. Anaphase:	
		D. Telophase:	

Task 4. Match the characteristics of proteins in the left column with their functions in the right one.

1. Form nuclear pore complex	A. Caspases
2. Form nucleosomes	B. Cyclins
3. Phosphorylate other proteins to activate or inactivate them	C. Cohesins
4. Take part in programmed cell death	D. Histones
5. Form nuclear lamina	E. Kinases
6. Bind homologous chromosomes together in meiosis	F. Condensins
7. Bind sister chromatids together	G. Lamins
8. Regulate cell cycle	H. Nucleoporins
9. Form the central scaffold of a metaphase chromosome	I. Synaptonemal complex

1	2	3	4	5	6	7	8	9

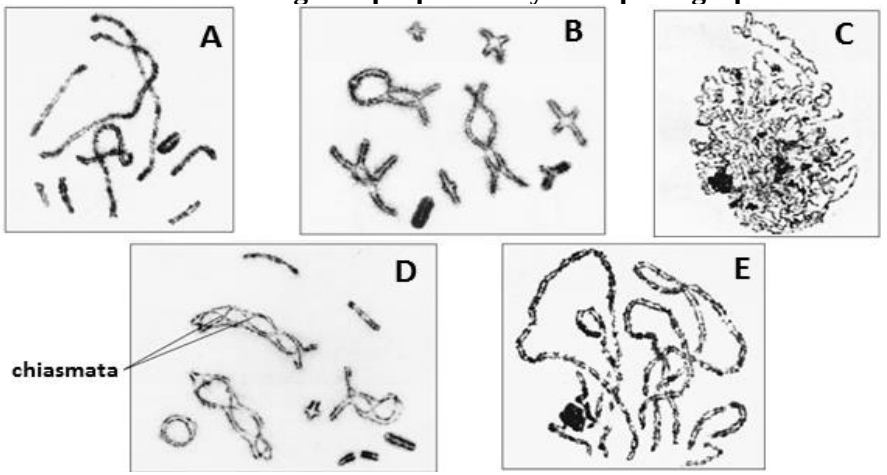
Task 5. Solve the case problems.

Case #1. The haploid cells 1 and 2 mutated and became unable to replicate their DNA. In cell 1 the mutations happened during the G1 phase while in cell 2 they happened during G2. What is the theoretical chance that the cells transmit their mutations to at least one of their daughter cells?

Case #2. The same gene mutated in cells 1 and 2 during interphase. After mitosis cell 1 transmitted the mutation to only one daughter cell and cell 2 – to both of them. How can this be explained?

Case #3. There is a protein with an unknown function. Its concentration in the cell is low and increases only during G2. How the inactivation of the gene coding for this protein could affect mitosis? Suggest your theories

Task 6. Determine the stages of prophase I by their photographs.



	Phase	
A		Crossing over occurs
B		The maximal condensation of chromosomes is reached
C		Condensation of chromatin starts
D		Synaptonemal complex breaks down, chiasmata appear
E		Chromosomal synapsis starts

Task 7. Draw the cells undergoing different phases of mitosis.

Interphase Prophase Metaphase Anaphase Telophase

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Class #5. Topic: **THE FLOW OF GENETIC INFORMATION IN THE CELL**

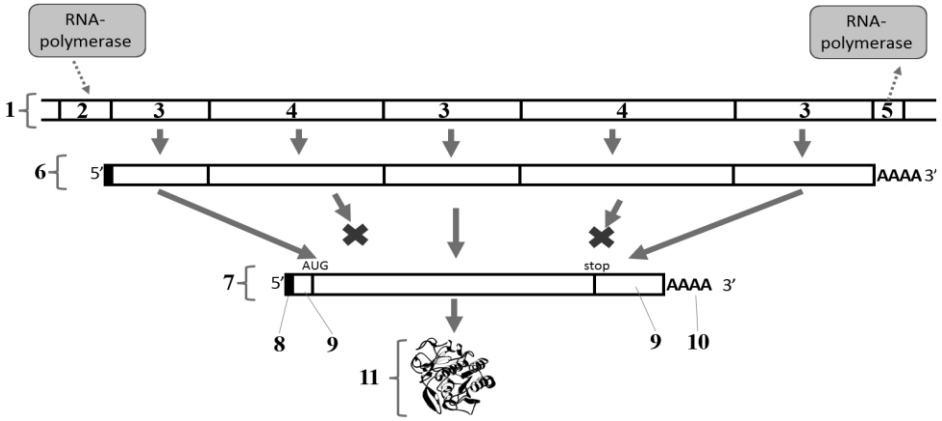
CONTENTS OF THE TOPIC

1. The Central Dogma of Molecular Biology.
2. The concept of the gene. Properties and functions of genes.
3. Ribonucleic acid, its types. The functions of RNA.
4. Genetic code and its properties.
5. Transcription. Transcription factors. Production of mRNA in eukaryotes: primary transcript and its processing.
6. Recognition. Translation: initiation, elongation, and termination.
7. Posttranslational modifications of proteins, folding of proteins. Chaperones.

GLOSSARY

1. **Promoter –**
2. **Intron –**
3. **Spliceosome –**
4. **Terminator –**
5. **Poly-A tail –**
6. **Penetrance –**
7. **Transcription factors –**
8. **Degeneracy of genetic code –**
9. **Aminoacyl-tRNA synthetase –**
10. **Capping –**
11. **Protein folding –**
12. **Chaperone –**
13. **Proteasome –**

Task 1. Label the diagram of gene expression.



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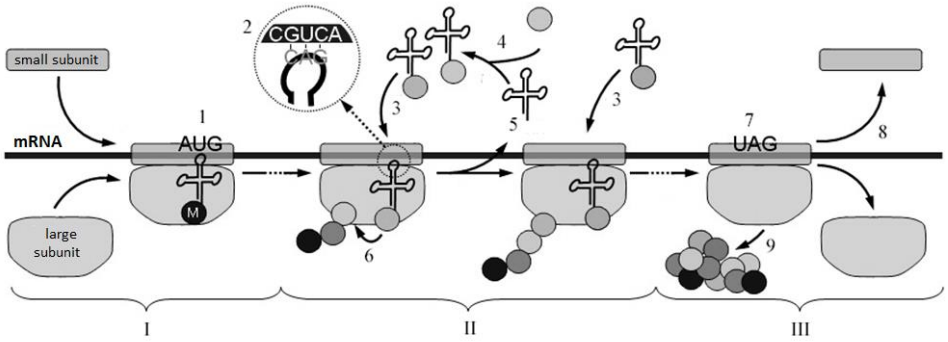
Task 2. Label the diagram of gene translation.



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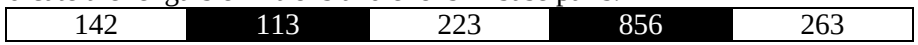
Task 3. Solve the problems.

Problem #1. A fragment of the human insulin gene contains 2,764 base pairs (bp). Three exons of the gene contain 42, 204, and 205 bp and are situated between sequences containing 904, 179, 787, and 443 bp. The entire first exon, the first 17 bp of the second one, and the last 62 pairs of the third one code for untranslated regions of mRNA. The 72 bp of the second exon code for a signaling sequence of amino acids that is removed from insulin. The last 25 bp and the first 80 bp of the second and third exons code for C-peptide, which is also removed from the insulin. How many amino acids does the ultimate insulin molecule contain? What is the percent of base pairs coding for that molecule in the gene fragment?

Problem #2. A fragment of adrenocorticotropic hormone (ACTH) produced by the anterior pituitary lobe has the structure: ser-ser-met-glu-his-phe-arg. What are possible tRNA anticodons variants involved in the biosynthesis of the ACTH fragment?

Problem #3. The distance between adjacent base pairs in DNA is 3.4×10^{-10} m. What is the length of the DNA region coding for 200 amino acids (without stop-codons)?

Problem #4. Here is a diagram showing the exons (white) and introns (black) of the HBB gene encoding β-globin, a subunit of human hemoglobin. The numbers indicate the lengths of introns and exons in base pairs.



A. How many nucleotides does this gene's mRNA contain?

B. The non-translated regions located at the 5' and 3' ends of this mRNA contain 50 and 134 nucleotides (the stop codon is not included). How many amino acids does beta-globin contain?

Problem #5. The average molar mass of a nucleotide is near 300 g/mol. There is a single-strand DNA of a bacteriophage and its molar mass is approximately 10^7 g/mol. The average number of amino acids in each protein of this phage is near 400. How many protein-coding genes can be in this DNA? The non-coding regions can be ignored for the simplicity of calculations.

Problem #6. Each turn of the DNA double helix is 3.4 nm long and contains 10 pairs of nucleotides. The protein fragment consists of 30 amino acid residues. What is the length in nm of the DNA region that encodes this protein fragment?

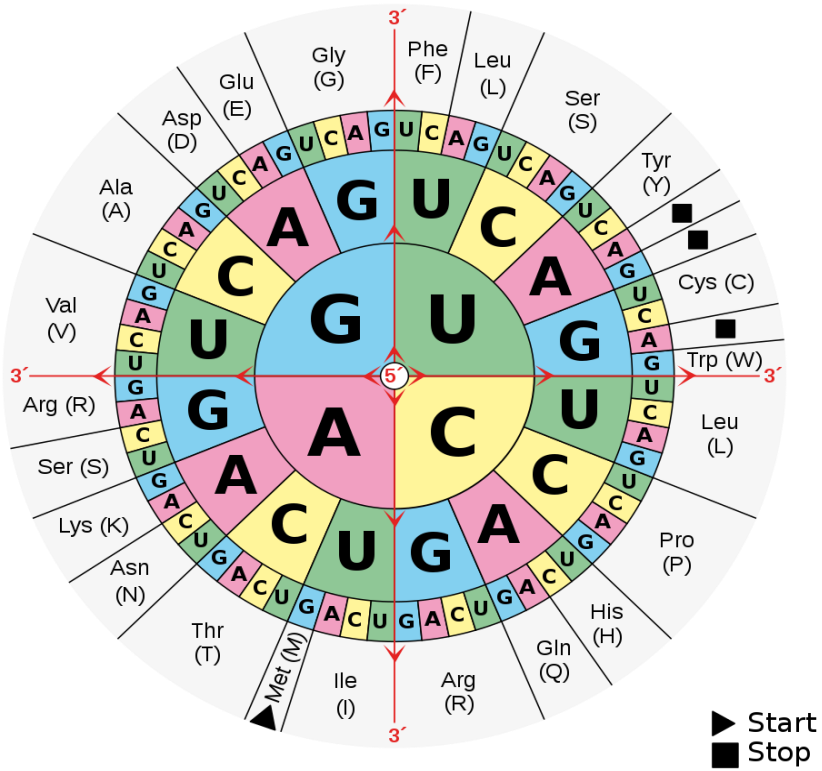


Fig. 1. Genetic code: mRNA codons and amino acids they code for

Problem #7. A fragment of the sense DNA strand has the following nucleotide sequence: GAGGCTCTAGGTACCAGT.
A) Find the nucleotide sequence of the antisense strand.
B) Find the mRNA fragment transcribed from this DNA (the template for mRNA is the antisense strand).
C) Label the DNA ends (3' or 5').
D) Find the amino acid sequence of the protein encoded by this DNA fragment.

The coding (sense) strand:

_' G A G G C T C T A G G T A C C A G T _'

A)

B)

D)

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Class #6. Topic: **REGULATION OF GENE EXPRESSION**

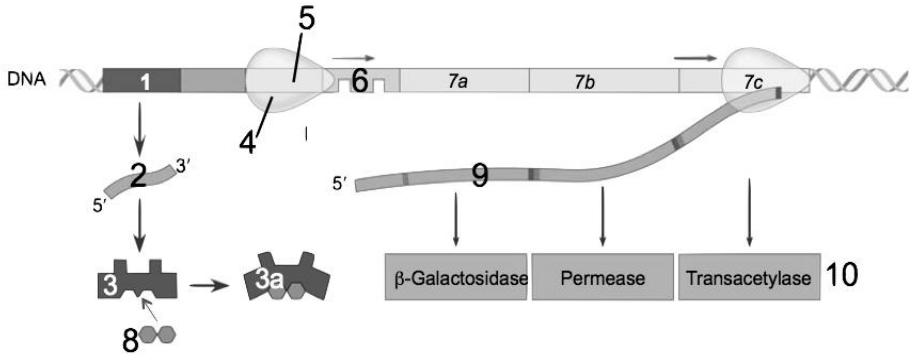
CONTENTS OF THE TOPIC

1. Human genome: protein-coding genes, RNA genes, non-coding sequences (repeats, introns, junk DNA). DNA transposons and retrotransposons. Transcriptome. Proteome. Metabolome.
2. Genome redundancy, its significance.
3. Projects Human genome, ENCODE, Roadmap.
4. Classification of genes (structural and functional genes, housekeeping, and tissue-specific genes).
5. Operon. Lac- and trp-operons. Polycistronic RNA.
6. Regulation of transcription in eukaryotes: preinitiation complex. Enhancers, silencers.
7. Epigenetics: histone modifications, cytosine methylation, CpG-islands,
8. Regulation of gene expression by non-coding RNAs.

GLOSSARY

1. **Gene expression –**
2. **Retrotransposon –**
3. **Single nucleotide polymorphism –**
4. **DNA methylation –**
5. **Housekeeping genes –**
6. **Chromatin remodeling –**
7. **Satellite DNA –**
8. **Enhancer –**
9. **Epigenetics –**
10. **Proteomics –**
11. **RNA interference –**
12. **Common transcription factors –**
13. **CpG-island –**

Task 1. Label the diagram of lac-operon.



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Task 2. Choose the term for each definition.

1. The specific structure of epigenetic modifications presents in the cell at a certain period	A. Proteome
2. Qualitative and quantitative set of all low-molecular-weight molecules present in the cell	B. Methylome
3. The entire sequence of DNA that characterizes a species, organism, or specific cell type	C. Genome
4. The entire set of proteins expressed in a given cell type or organism, at a given time under given conditions	D. Epigenome
5. The specific set of transcripts (RNA molecules) present in cells of a particular type	E. Metabolome
6. A specific pattern of DNA methylation presents at a particular time in the genome or a particular cell type	F. Transcriptome

1	2	3	4	5	6

Task 3. Put «+» to the factors that usually promote gene expression and «-» to those that suppress it.

Removal of nucleosomes from the promoter	
Interaction of microRNA (as part of RISC) with mRNA	
Histone acetylation	
Deletion of poly-A tail of mRNA	
Histone methylation	
Interaction of the preinitiation complex with an enhancer	
Methylation of cytosine in the promoter region	
Interaction of the preinitiation complex with a silencer	
Introduction of double-stranded RNA with gene sequence into the cell	

Task 4. Solve the problems.

Problem #1. Researchers studied the expression of a particular gene and discovered that deleting a DNA region located 50,000 upstream from the promoter of the gene significantly reduces the production of protein encoded by the gene. Deleting neighboring regions had no such effect. How can this be explained?

Problem #2. Researchers performed experiments with two groups of mice: in the first group the color of the coat was yellow. In the second group, it was dark. These traits were inherited. However, it was found that adding folic acid to the diet of pregnant yellow-colored mice makes the color of little mice dark. How could this be explained?

Problem #3. One of the operons of a certain bacterium contains five genes. Gene **A**, which is closest to the promoter, and gene **B**, which is farthest from the promoter, are approximately equal in length. However, it was found that the protein encoded by gene A commonly appears in the cell earlier than the protein encoded by gene B. How can this difference be explained?

Problem #4. A hypothetical bacterial mRNA contains 3 cistrons. The first one (near the 5' end) has 999 nucleotides, the second one has 2001, and the third one is 3000 nucleotides.

How much time does it take the bacterium to translate each gene at least one time (ignore the time for transcription)? Bacteria can translate at a rate of 17 amino acids per second.

Problem #5. Let's take a hypothetic operon where each promoter, operator, and terminator contain 10 base pairs. This operon has 3 structural genes, each code for a protein consisting of 50 amino acids. What is the number of nucleotides in this operon? Any other regions can be ignored for simplicity.

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Class #7. Topic: **GENOMICS. TECHNIQUES OF MOLECULAR GENETICS**

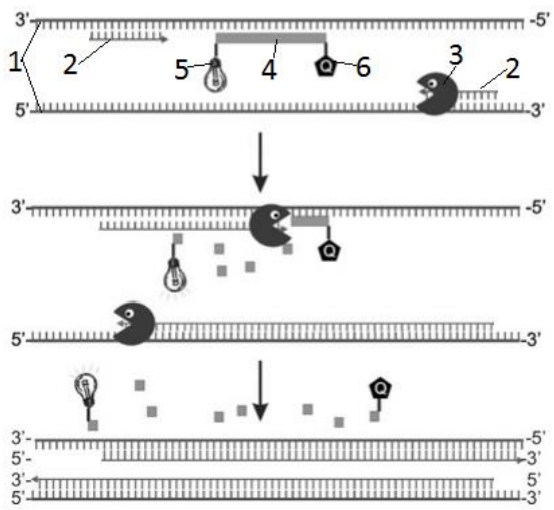
CONTENTS OF THE TOPIC

1. Methods of nucleic acids isolation.
2. DNA research methods: gel electrophoresis, restriction analysis, nucleic acid hybridization, DNA microarrays, PCR, sequencing.
3. PCR and its types: quantitative PCR, reverse transcription PCR, multiplex PCR.
4. Genome sequencing methods (Sanger sequencing, pyrosequencing, nanopore sequencing, bisulfite sequencing).

GLOSSARY

1. **Gel electrophoresis** –
2. **Restriction endonuclease** –
3. **DNA probe** –
4. **DNA sequencing** –
5. **Sanger sequencing** –
6. **Dideoxynucleotide** –
7. **Restriction analysis** –
8. **Nucleic acid hybridization** –
9. **Polymerase chain reaction** –
10. **DNA microarray** –
11. **Dideoxynucleotide** –
12. **Bisulfite sequencing** –
13. **Quantitative PCR** –
14. **Intercalating dye** –

Task 1. Label the diagram of quantitative PCR.



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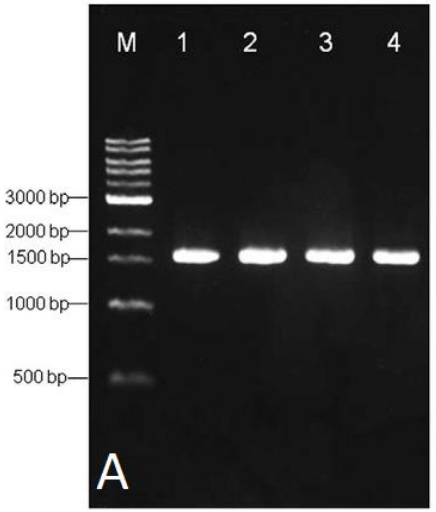
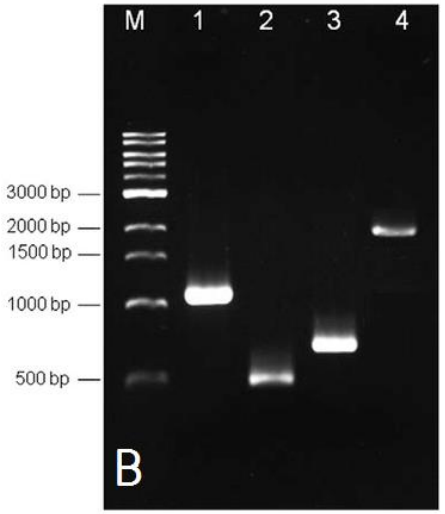
Task 2. Match the sequencing method with its characteristic (write the correct letter in the table): a) Sanger sequencing; b) pyrosequencing; c) nanopore sequencing; d) bisulfite sequencing.

Uses nucleotides lacking a 3' OH group	
Known as the chain termination method	
Based on the measurement of ion current through a non-conductive membrane	
The nucleotide sequence is determined by chemiluminescence	
Uses a nanopore in a special membrane	
Reveals methylated cytosine in the DNA	
Nucleotide sequencing is determined by differences in the length of synthesized DNA fragments	

Task 3. Solve the problems.

Problem #1. The photograph shows an agarose gel in which DNA is visualized after electrophoresis. Using a length marker (labeled as "M"), determine the approximate length of the presented fragments in base pairs.





A: 1 – B: 1 –

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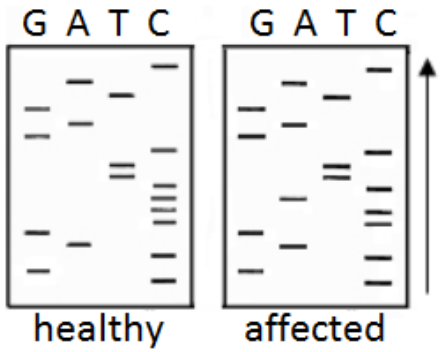
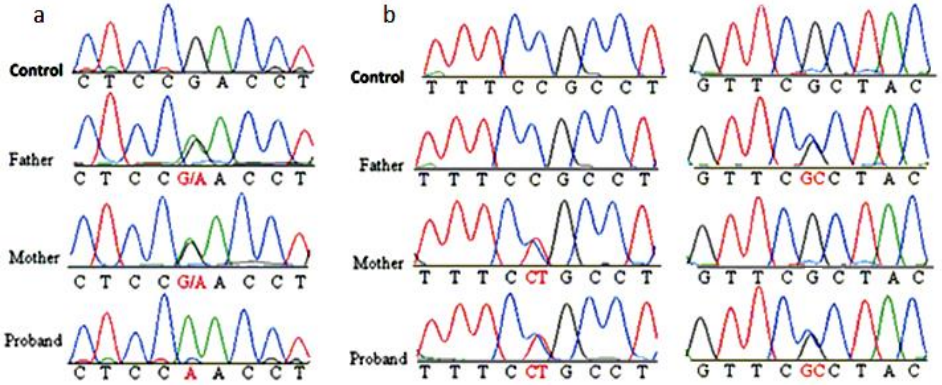
Problem #2. Restriction endonuclease *Hind*III recognizes and cuts the site 5' AAGCTT3'. What is the chance of finding this nucleotide combination in a random DNA? What is the expected average length of the fragments formed when the DNA is cut by *Hind*III?

Problem #3. Theoretically, after each PCR cycle, the amount of DNA is doubled. How many minutes would it take to obtain one million copies from one molecule? The denaturing, annealing, and extension last 15, 30, and 90 seconds.

Problem #4. The gene *RHO* encodes the protein called rhodopsin. Various mutations in this gene cause a hereditary disorder retinitis pigmentosa that causes loss of vision.
Sanger sequencing was performed. The diagram shows a fragment of the coding strand from the *RHO* gene (bases encoding 21st-27th amino acids). Read the codons from the first nucleotide at the bottom of the figure. Which mutation occurred in the sick person? What is the change in the amino acid sequence in the protein?



Problem #5. Mutations in the *PAH* gene cause phenylketonuria. The disease is autosomal recessive (develops when the gene *PAH* is altered in both chromosomes). Here are the results of Sanger sequencing of the *PAH* gene for two families.
In family A, both parents have a c.728G>A mutation in exon 7, i.e., replacing the 728th G nucleotide with A.
In family B, one parent has the mutation c.721C>T (replacing CD with T) and the other has the mutation c.1238G>C (replacing G with CD).
Examine the data in the figure and conclude whether children in both families have the disease or not. Explanation: control is the gene regions of other individuals without mutations that are needed for comparison; G, C, A, T are the Latin notations for G, C, A, and T shown by the software that processes the sequencing data.



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Class #8. Topic: **GENETIC ENGINEERING**

CONTENTS OF THE TOPIC

1. Genetic engineering: goals, objectives, and stages.
2. Methods for obtaining genes for transgenesis.
3. Recombinant DNA. Construction of vectors, their types.
4. Introduction of recombinant DNA into a recipient cell. Selection of transformed cells. Selective and reporter genes.
5. Biotechnology, its importance for medicine. Genetically modified organisms. Food products containing GMOs.

GLOSSARY

1. **Vector –**
2. **Recombinant DNA –**
3. **Transgenesis –**
4. **Polylinker –**
5. **Reporter genes –**
6. **Selectable marker genes –**
7. **Shuttle vector –**
8. **Lipofection –**
9. **Electroporation –**
10. **Transformation –**
11. **Sticky ends –**
12. **DNA cloning –**
13. **Biolistics –**
14. **Phagemids –**

Task 1. Match the method of introducing recombinant DNA into a cell with its name.

1. The method is based on the ability of bacteria to take up DNA molecules from a solution	A. transduction
2. Delivery of DNA into a cell in a vesicle with one or more bilipid layers	B. Electroporation
3. Transfer of recombinant DNA into a bacterial cell using a bacteriophage	C. Lipofection
4. Direct introduction of DNA into the nucleus with a thin needle	D. Transformation
5. Formation of temporary channels in the membrane by electric impulses	E. Microinjection

1	2	3	4	5

Task 2. Label the diagram of cloning a human gene in a bacterial cell.

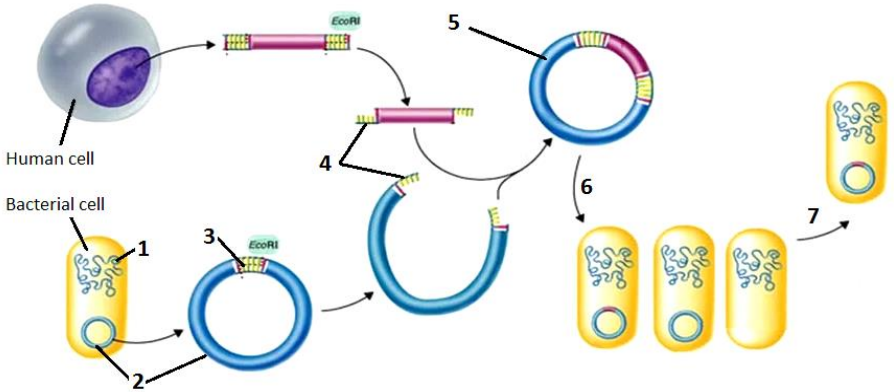

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Table 1

Some restriction endonucleases and their restriction sites

#	Restriction endonuclease	Restriction sites and cut points
1	***Bal*I**	5 ' – T G G▼C C A – 3 ' 3 ' – A C C▲G G T – 5 '
2	***Bam*HI**	5 ' – G▼G A T C C – 3 ' 3 ' – C C T A G▲G – 5 '
3	***Eco*RI**	5 ' – G▼A A T T C – 3 ' 3 ' – C T T A A▲G – 5 '
4	***Hind*III**	5 ' – A▼A G C T T – 3 ' 3 ' – T T C G A▲A – 5 '
5	***Sal*I**	5 ' – G▼T C G A C – 3 ' 3 ' – C A G C T▲G – 5 '
6	***Xba*I**	5 ' – T▼C T A G A – 3 ' 3 ' – A G A T C▲T – 5 '
7	***Hae*III**	5 ' – G G▼C C – 3 ' 3 ' – C C▲G G – 5 '

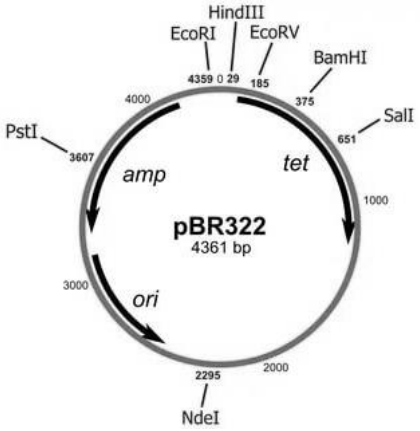
Task 3. Solve the problems.

Problem #1. There is a 27-bp DNA fragment:

```
5'-CTGAATTAGGATCCAGGCAATAGTGTG-3'
3'-GACTTAATCCTAGGTCCGTTATCACAC-5'
```

What endonuclease from the table can cut this DNA? How many fragments will be formed?

Problem #2. The figure shows plasmid pBR322 with its restriction sites. Which of the following double-stranded DNA fragments can be inserted into the plasmid if only the endonucleases from table 1 are available?



#1.
5'-CCGAATTCAGATGTAAGGCAATAGTGTGAATTCACA-3'
3'-GGCTTAAGTCTACATTCCGTTATCACACTTAAGTGT-5'

#2.
5'-CCTTAAGCTGAGGCTAAGGCAATAGAAGCAACACATG-3'
3'-GGAATTCGACTCCGATTCCGTTATCTTCGTTGTGTAC-5'

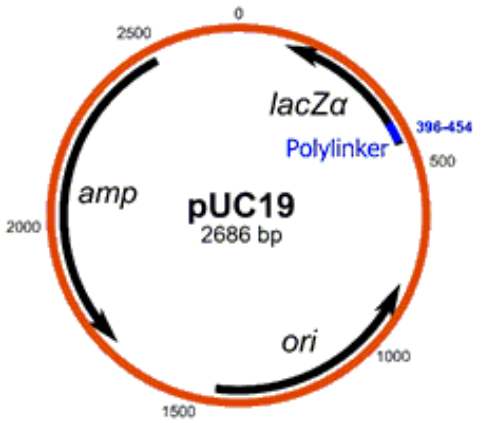
#3.
5'-AGGCCGATACCCGATACTCGACCGATACTGTAGGCCG-3'
3'-TCCGGCTATGGGCTATGAGCTGGCTATGACATCCGGC-5'

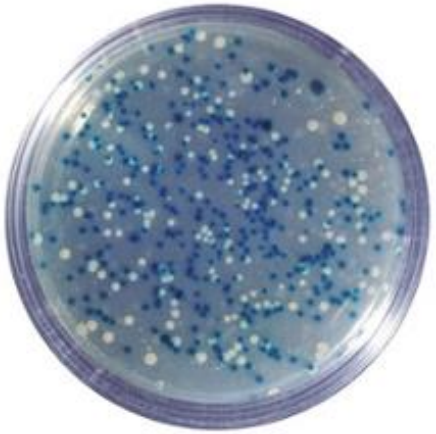
Problem #3. The pUC19 plasmid contains:

- The gene for resistance to the antibiotic ampicillin (*amp*).
- The gene *lacZα*, allows bacteria to produce a blue substance from another substance called X-gal.
- Polylinker (a region containing multiple restriction sites) is located within the *lacZα* gene.

Cells transformed with recombinant pUC19-based DNA were seeded on a medium containing ampicillin and X-gal. White and blue colonies grew on the medium (each colony was a group of bacterial offspring of one cell).

1. What is the fate of bacteria that have not transformed (i.e. without pUC19)?
2. What is the fate of bacteria that have pUC19 but are without the desired gene?
3. Which color colonies were successfully genetically modified?





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Class #09. Topic: **BASIC LAWS OF INHERITANCE**

CONTENTS OF THE TOPIC

1. Genetics as a science.
2. Hybridological analysis.
3. Laws of inheritance in a monohybrid cross. Law of purity of gametes. Test-cross. Backcrossing.
4. Laws of inheritance in polyhybrid cross.
5. Limitations of Mendel's laws. Pleiotropy.
6. Intraallelic gene interactions (complete and incomplete dominance, super-dominance, codominance, and allelic exclusion).
7. Multiple alleles. Inheritance of blood groups in the ABO system. Inheritance of MN blood groups and Rh factor.
8. Interallelic interaction of genes (complementary, inhibitory, polymeric gene action). Bombay blood group as an example of recessive epistasis in humans.

GLOSSARY

1. Allele –

2. Complementation –

3. Superdominance –

4. Testcross –

5. Phenotype –

6. Polymeric gene action –

7. Codominance –

8. Genotype –

9. Backcrossing –

10. Epistasis –

11. Intraallelic interactions –

12. Allelic exclusion –

13. Pure lines –

Task 1. Solve the problems.

Problem #1. How many and what types of gametes could be formed by organisms with the following genotypes?

P: AaBbDd AAbbCCddRR

Problem #2. A blue-eyed male married a brown-eyed female. Her father was blue-eyed and her mother was brown-eyed. It's known that the allele of brown eyes is dominant. What phenotypes of children could be expected in this family and what is their chance?

Problem #3. In humans, brown eyes and dextrality (right-handedness) are determined by the dominant alleles of two different genes. The blue eyes and sinistrality (left-handedness) are determined by their recessive alleles. A browned-eyed right-hander man married a blue-eyed left-hander woman. What traits could be expected in children if the man is double-heterozygous?

Problem #4. A woman has blood groups O, Rh-, MN. Her husband has groups AB, Rh+ (homozygote), and N. What combinations of blood groups can their children have?

Phenotype	Gene	Genotype
System AB0		
Group 0 (I)	I^0	I^0I^0
Group A (II)	I^A	I^AI^A, I^AI^0
Group B (III)	I^B	I^BI^B, I^BI^0
Group AB (IV)	$I^A + I^B$	$I^A I^B$
System MN		
Group M	L^M	L^ML^M
Group N	L^N	L^NL^N
Group MN	L^M+L^N	L^ML^N
System Rh		
Rh+	D	DD, Dd
Rh-	d	dd

Problem #5. In humans, congenital deafness can be caused by recessive alleles of two different genes (**d** and **e**). Normal hearing requires dominant alleles of both the genes (**D** and **E**). There is a family where parents are deaf while all their seven children have normal hearing. What are the most probable genotypes of all members in this family?

Problem #6. In "Fleur" begonia, leaf variegation is caused by a recessive allele of the gene ***f***, and in "Sank" begonia by a recessive allele of the gene ***s*** (genes are in different chromosomes). When two dihomozygous variegated plants of these varieties are crossed, all resulting hybrids have green leaves. How many begonias (in %) among plants with green leaves (F2) will carry only one (any) variegated leaf gene?

Problem #7. Two genes are responsible for coloration in pigs. In the crossing of dihomozygous black and white pigs of different breeds, all the offspring have white coloration. Among the F2 hybrids, 96 piglets were white, 24 were black, and 8 were red. How many (in %) of the offspring from an F1 boar and a black homozygous pig will be red?

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Class #10. Topic: **GENETIC LINKAGE. GENETICS OF SEX**

CONTENTS OF THE TOPIC

1. Experiments of T. Morgan. Complete and partial genetic linkage. Linkage groups.
2. Crossing-over.
3. Chromosomal theory of inheritance.
4. Genetic and cytological chromosome maps.
5. Sex as a biological trait. Sex-influenced and sex-limited traits. X and Y linked traits.
6. Definition, differentiation, and redefinition of sex in ontogeny. Genetic regulation of gonadogenesis in humans.
7. Peculiarities of sex determination in humans: physical, intermediate and socio-psychological determinants.
8. Disorders of sex development in humans. Ethical and legal aspects of morphological and civil sex changes.
9. X-inactivation. M. Lyon's hypothesis of female mosaicism by sex chromosomes.

GLOSSARY

1. **Linked genes –**
2. **Sex-linked genes –**
3. **Crossover gametes –**
4. **Chromosomal theory of sex determination –**
5. **Genetic map of chromosome –**
6. **Primary sexual characteristics –**
7. **Heterogametic sex –**
8. **Barr body –**
9. **Mosaicism –**
10. **Androgen insensitivity syndrome –**
11. **Holandric traits –**
12. **Hemizygosity –**
13. **Genetic sex –**

Task 1. Solve the problems.

Problem #1. Write the gametes and their percentages for Drosophila with the following genotypes (the distance between the linked genes is 28 cM).

1. male $\frac{A}{a}\ \frac{B}{b}$ 2. male $\frac{AB}{ab}$ 3. female $\frac{AB}{ab}$ 4. female $\frac{AB}{ab}\ \frac{D}{d}$

Problem #2. The distance between the autosomal gene that determines the Lutheran antigens and the gene that determines the solubility of some blood proteins is 13 cM. What is the percentage of non-crossover gametes in a double-heterozygous human?

Problem #3. What is the probability of giving birth to a recessive homozygous child in a family of people with the following genotypes? The distance between the genes A and B is 20 cM.

P: $\frac{AB}{ab}$ x $\frac{AB}{ab}$

G:

◯ - %	◯ - %
◯ - %	◯ - %
◯ - %	◯ - %
◯ - %	◯ - %

F1:

Answer:

Problem #4. Two patients, 15 and 18 years old with a female phenotype, have primary amenorrhea. Clinical examination revealed underdevelopment of primary sex characteristics. Barr body was not detected. The karyotype was determined to be 46, XY. Male sex hormone levels were not elevated, but closer to the upper limit of the normal range. Sequencing of the *AR* gene was performed to verify one of the suspected causes of the disease, which revealed a nonsense mutation c.2657T>A - codon TAA instead of TAT. As result, the protein encoded by this gene is not being produced. What diagnosis was confirmed by sequencing of the *AR* gene? What does this gene encode?

Problem #5. Elliptocytosis and blood group Rh+ are determined by the dominant alleles of genes **El** and **D** respectively. Both the genes are situated in the same chromosome at a distance of 3 cM. There is a man who is heterozygous for both genes. He inherited Rh+ from his mother and elliptocytosis from his father. His wife has blood group Rh- and normal erythrocytes. What phenotypes can their children have and what is their chance in percent?

Problem #6. Hemophilia and color blindness are caused by the recessive alleles of two different genes (h and d). The genes are situated in the X chromosome at a distance of 10 cM. A woman whose father had both the diseases and mother had no such recessive alleles married a healthy man. What is the probability of giving birth to a child: 1) with both diseases; 2) with one disease; 3) phenotypically healthy?

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Class #11. Topic: **VARIATION. MUTAGENESIS. CARCINOGENESIS**

CONTENTS OF THE TOPIC

1. Variation and its types. Phenotypic plasticity.
2. Combinative variation.
3. Mutations. Causes of mutations: DNA copying errors, unequal crossing over, mutagens.
4. Physical, chemical, and biological mutagenic factors. Genetic hazards of environmental pollution by mutagens.
5. Classifications of mutations.
6. Stability and repair of genetic material.
7. Types of DNA repair. Excision repair, repair of double-stranded breaks. Photoreactivation. Role of repair disorders in human pathology.
8. Carcinogenesis. Oncogenes and tumor suppressor genes.

GLOSSARY

1. Mutation –

2. Unequal crossing over –

3. Reparation of genetic material –

4. Insertion –

5. Reading frameshift –

6. Phenocopies –

7. Anaphase lag –

8. Non-homologous end joining –

9. Oncogene –

10. Tumor suppressor genes –

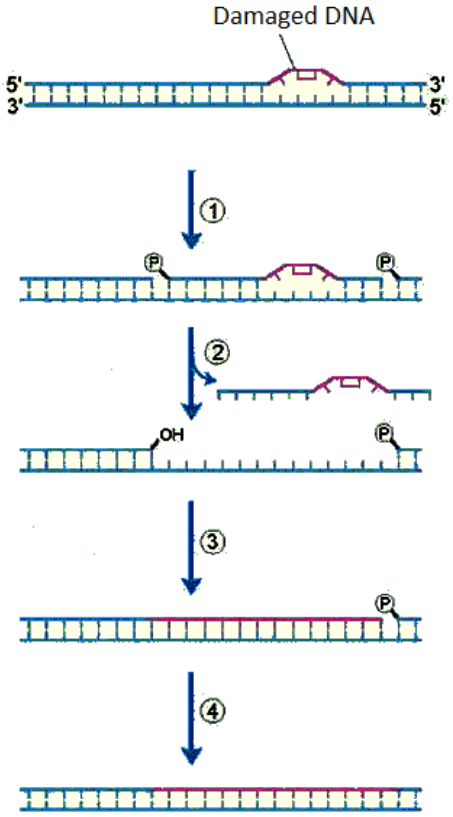
11. Reciprocal translocation –

12. Combinative variability –

13. Transversion –

14. Missense mutation –

Task 1. Label the figure of nucleotide excision repair and explain its mechanism.



1 –

2 –

3 –

4 –

Task 2. Match the DNA repair mechanism with its name.

1. Error-prone mechanism for joining double-stranded breaks	A. Direct reversal
2. Single nucleotide is replaced	B. Nucleotide excision repair
3. Method by which pyrimidine dimers are eliminated in humans	C. Base excision repair
4. Damage is repaired without nucleotide replacement	D. Nonhomologous end joining
5. Repair involving proteins with endo- and exonuclease activity and subsequent filling in the gap in the DNA strand with DNA-polymerase	E. Reparation by homologous recombination
6. Use of the sequence of homologous chromosome or sister chromatid to repair double-stranded breaks	F. Mismatch repair

1	2	3	4	5	6

Task 3. Model changes of proteins in case of different point mutations.

Initial mRNA	5’ A U G A C C G A C C C G A A A G G G A C C 3’
Peptide	
Silent mutation	5’ A U G A C C G A C C C **C** A A A G G G A C C 3’
Peptide	
Missense mutation	5’ A U G **C** C C G A C C C G A A A G G G A C C 3’
Peptide	
Nonsense mutation	5’ A U G A C C G A C C C G **U** A A G G G A C C 3’
Peptide	
Frameshift mutation	5’ A U G A C C G A C **G** C C G A A A G G G A C C 3’
Peptide	

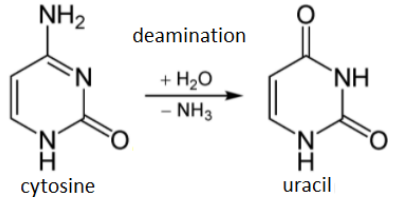
Task 4. Solve the problems.

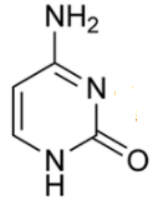
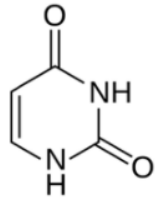
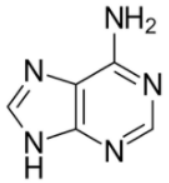
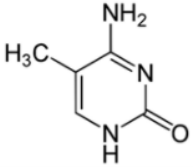
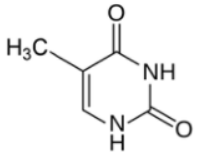
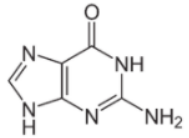
Problem #1. Some cells of a person have a normal karyotype, others have 47 or 45. What is the name of this phenomenon? What is the mechanism of its origination?

Problem #2. A man has got brown eyes, his wife has got blue eyes and their daughter has one blue and the other brown eyes. How can it be explained?

Problem #3. Aged spouses got a son who is heterozygous in the gene of hemophilia. What conclusion about his karyotype can be drawn?

Problem #4. Every day in every human cell about 200 cytosines per haploid genome are converted to uracil by spontaneous deamination. What does deamination of cytosine lead to, provided it is methylated?



		
cytosine	uracil	adenine
		
5-methylcytosine	thymine	guanine

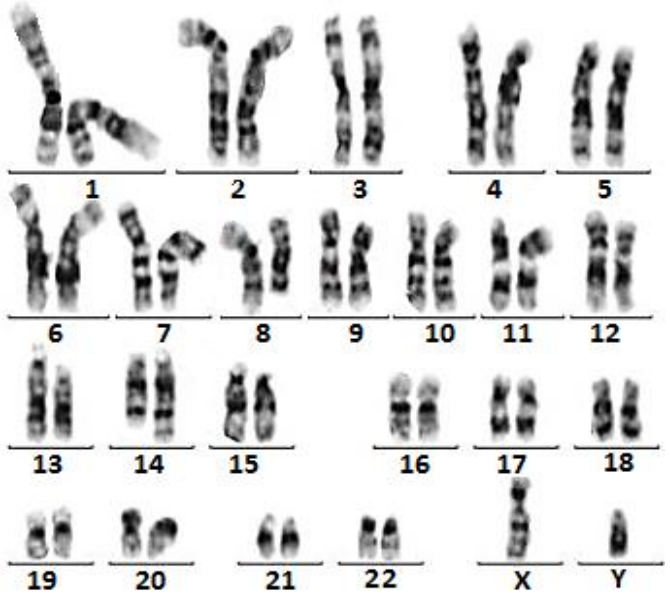
Problem #5. Burkitt's lymphoma (cancer that develops from B-lymphocytes) is known to develop because of an increase in the activity of the *C-MYC* oncogene located in chromosome 8. The disease can be caused by several aberrations:

a) translocation of a q-arm fragment from chromosome 8 to the q-arm of chromosome 14;

b) translocation of a p-arm fragment from chromosome 2 to the q-arm of the chromosome 8;

c) translocation of the q-arm region from chromosome 8 to the q-arm of chromosome 22.

Is one of these mutations present in the chromosomes shown in the photograph? Explain your answer.



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Class #12. Topic: **POPULATION GENETICS**

CONTENTS OF THE TOPIC

1. Population. Characteristics of a population. Gene pool.
2. Ideal population. Hardy-Weinberg equilibrium.
3. Factors disturbing Hardy-Weinberg equilibrium: natural selection, genetic drift, mutations, migration, non-random mating.
4. Human genetic polymorphism, its biological, medical, and social aspects. Distinctive features of the human population. Types of marriages. Inbreeding. Mating assortativity. Inbreeding coefficient.
5. Large and small populations. Peculiarities of the gene pool of isolates. Founder and bottleneck effects.
6. Effects of elementary evolutionary factors on human populations.
7. Genetic load, its biological essence, and medical significance.

GLOSSARY

1. **Population –**
2. **Gene pool –**
3. **Natural selection –**
4. **Genetic drift –**
5. **Immigration –**
6. **Founder effect –**
7. **Inbreeding –**
8. **Genetic load –**
9. **Inbreeding coefficient –**
10. **Assortative mating –**
11. **Bottleneck effect –**

Task 1. Solve the problems.

Problem #1. In a study of 4,300 individuals from a certain population, it was found that 3,009 of them could feel the bitter taste of phenylthiocarbamide (PTC), while 1,291 could not. The ability to taste PTC is determined by the dominant allele of an autosomal gene. Based on these data, calculate the frequencies of the dominant and recessive alleles and the frequencies of the genotypes that should be observed in this population.

Problem #2. Sickle cell anemia is an autosomal recessive disorder. Heterozygous carriers of the disease have increased protection against severe forms of malaria. The incidence of sickle cell anemia in some African countries (e.g. Nigeria) is about 2%. Calculate the percentage of people who have an increased protection against severe forms of malaria in these countries.

Problem #3. Cystic fibrosis is an autosomal recessive disorder. The incidence of this disease in the Republic of Belarus is about 1:8000. Based on these data, calculate the probability to carry this allele (frequency of heterozygotes) for the people living in Belarus. Taking these data into account, determine what is the probability of giving birth to a child with cystic fibrosis in a family where the mother is heterozygous and the father is phenotypically healthy, but his exact genotype is not known.

Problem #4. Phenylketonuria (PKU) is inherited in an autosomal recessive manner. The incidence of PKU in Belarus is about 1:6000. Calculate the probable number of heterozygous carriers of the disease in Belarus (in thousands) assuming the population is 9408.4 thousand.

Problem #5. In a population, the incidence of X-linked recessive color blindness among women is about 0.5%. What is the incidence of the disease in males of this population?

Problem #6. Congenital dislocation of the hip may be caused by the dominant allele of an autosomal gene with an average penetrance of 25%. According to one research (Efroimson et al., 1968), the frequency of this pathology is 6:10000. What is the frequency of recessive homozygotes in the studied population?

Problem #7. Assume there is a disease with an autosomal dominant pattern of inheritance and incidence 1:50. This disease occurs only in males and the penetrance of the gene is 20% (in females it is 0%). Taking the ratio of males to females as 1 : 1, determine the genetic structure of the population according to the analyzed trait.

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Class #13. Topic: **HUMAN GENETICS**

CONTENTS OF THE TOPIC

1. Humans as a specific object of genetic analysis.
2. Methods of human genetics: genealogical analysis, twin study, biochemical tests, molecular-genetic methods.
3. Methods of diagnosing human chromosomal diseases: standard karyotyping, SKY, FISH, and single-nucleotide polymorphism array karyotyping.
4. Rapid diagnostic methods: microbiological tests, detection of X- and Y-sex chromatin, biochemical tests, genetic dermatoglyphics.
5. Neonatal screening of monogenic disorders.

GLOSSARY

1. Karyotyping –

2. DNA probe –

3. Prenatal diagnosis –

4. Concordance of twins –

5. Rapid diagnostic methods –

6. Holzinger's formula –

7. Spectral karyotyping –

8. Pedigree –

9. Fluorescence in situ hybridization –

10. Screening –

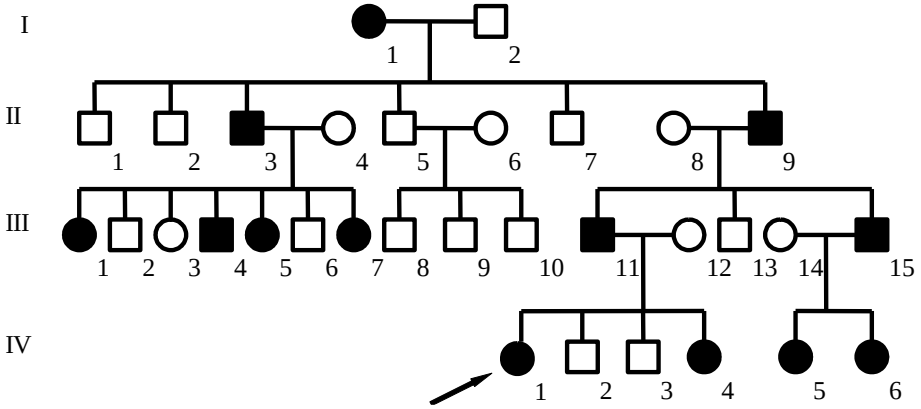
11. Propositus –

12. Single transverse palmar crease–

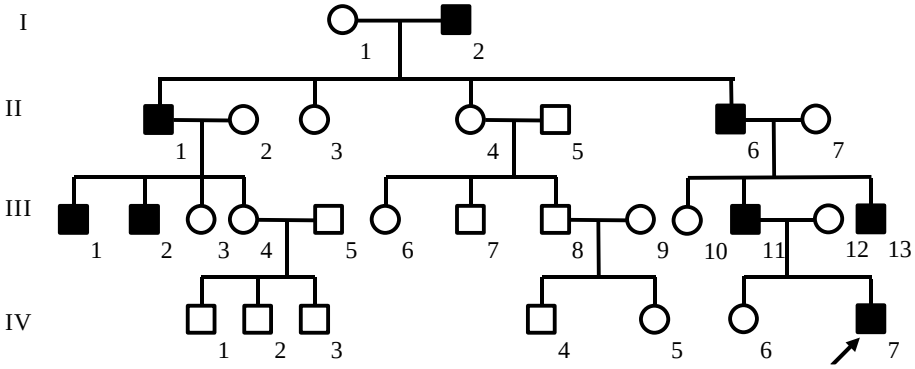
13. Medical Genetics–

Task 1. Solve the problems.

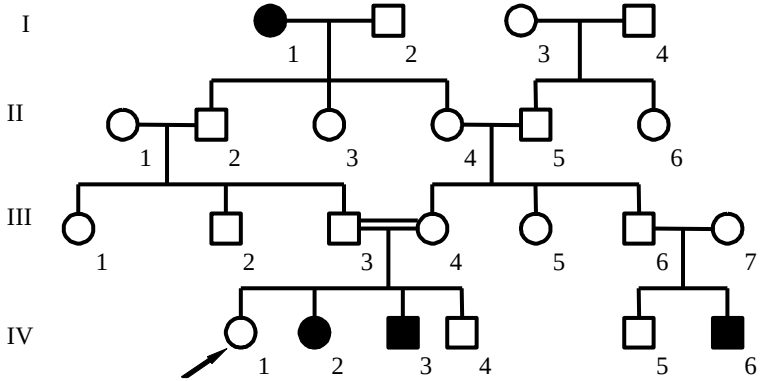
Problem #1. What is the pattern of inheritance of the trait from the pedigree? What are the genotypes of all pedigree members?



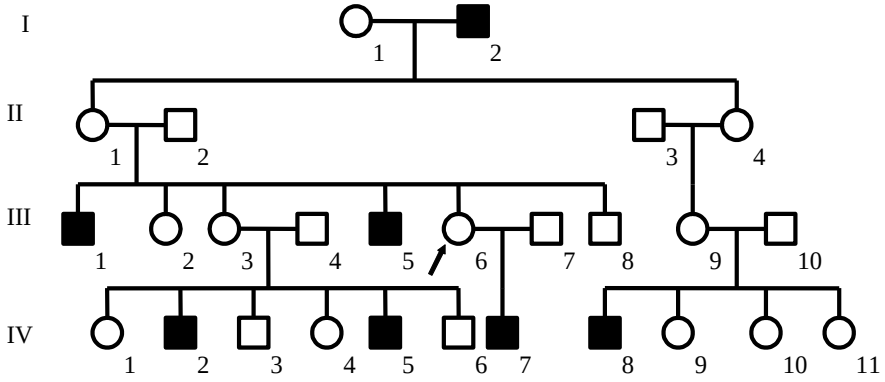
Problem #2. What is the pattern of inheritance of the trait from the pedigree? What are the genotypes of all pedigree members?



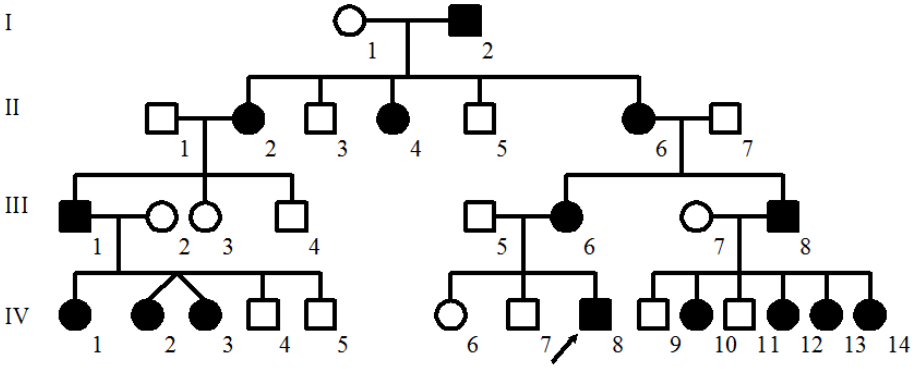
Problem #3. What is the pattern of inheritance of the trait from the pedigree? What are the genotypes of all pedigree members?



Problem #4. What is the pattern of inheritance of the trait from the pedigree? What are the genotypes of all pedigree members?



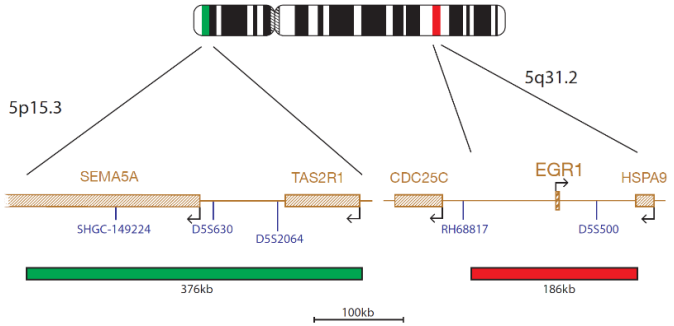
Problem #5. What is the pattern of inheritance of the trait from the pedigree? What are the genotypes of all pedigree members?



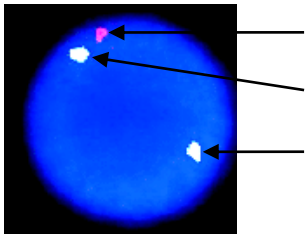
Problem #6. The concordance of monozygotic and dizygotic twins in body mass is 80% and 30%. What is the degree of genetic determination of body mass? What is the influence of the environment on this trait?

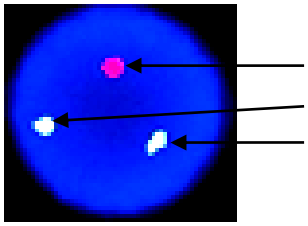
Problem #7. To determine the degree of genetic determination of bronchial asthma, 44 pairs of monozygotic and 120 pairs of dizygotic twins were studied. Twenty-three pairs of monozygotic twins and six pairs of dizygotic twins had bronchial asthma. Estimate the role of hereditary and environmental factors in the formation of this trait?

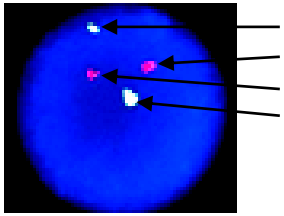
Problem #8. FISH was used to detect a deletion in the long arm of the fifth chromosome. The signals from the probes to the p- and q-arms of this chromosome are green and red, respectively.



Which cells of the following have a 5q deletion







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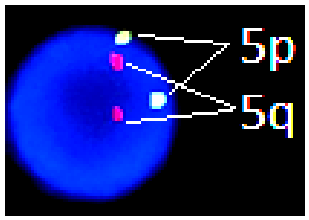

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Class #14. **COLLOQUIUM**

CONTENTS

1. The nature of life, and the role of proteins and nucleic acids in the organization of living systems. Organization levels of living matter. The cell theory.
2. Prokaryotes and eukaryotes.
3. Human as a biological and social being.
4. The role of biology in medical education.
5. Subject, objectives, and methods of cytology (light, electron, and fluorescent microscopy, histochemistry and immunohistochemistry, differential centrifugation, autoradiography, morphometry, etc.).
6. The method of light microscopy. The structure of a light microscope. The rules of work with a microscope.
7. The structure of the plasma membrane.
8. Transport across the membrane: passive transport (simple diffusion, facilitated diffusion, osmosis), active transport, endocytosis, exocytosis.
9. Cytosol. Cytoskeleton: microtubules, intermediate filaments, microfilaments. Intracellular transport of substances.
10. Assimilation. Ribosomes.Endomembrane system (nuclear envelope, endoplasmic reticulum, Golgi body, lysosomes, peroxisomes, endosomes, vesicles).
11. Dissimilation. Mitochondria. Lysosomal and peroxisomal disorders.
12. Evolution of the gene concept. Evidence that DNA is the genetic material.
13. Structure and functions of DNA. Genetic material of viruses and bacteria.
14. The structure and functions of the cell nucleus.
15. Gene, chromosome, and genome levels of eukaryotic genetic material.
16. DNA condensation. Remodeling of chromatin.
17. The structure of metaphase chromosomes. Euchromatin and heterochromatin. Types of chromosomes. Rules of chromosomes.
18. Karyotype and idiogram. Methods for studying the human karyotype. Classifications of human chromosomes.
19. Cytoplasmic inheritance.
20. Cell cycle. Interphase.
21. Semi-conservative mechanism of DNA replication. Replicon.
22. Cell cycle regulators (cyclins and cyclin-dependent kinases).
23. Types of cell division: mitosis, amitosis, endomitosis. Binary division of bacteria. Mitosis: characteristics of phases, distribution of genetic material, biological significance. Meiosis as a type of mitosis: characteristic of phases, distribution of genetic material, biological significance.
24. Cell proliferation and cell death. Necrosis and apoptosis. Caspases.
25. The Central Dogma of Molecular Biology.
26. The concept of the gene. Properties and functions of genes.
27. Ribonucleic acid, its types, functions. Genetic code and its properties.
28. Transcription. Transcription factors. Production of mRNA / mRNA synthesis in eukaryotes: primary transcript and its processing.
29. Recognition. Translation: initiation, elongation, and termination.
30. Posttranslational proteins modifications, protein folding, chaperones.
31. Human genome: protein-coding genes, RNA genes, non-coding sequences (repeats, introns, junk DNA). DNA transposons and retrotransposons. Transcriptome. Proteome. Metabolome. Genome redundancy, its significance.
32. Projects Human genome, ENCODE, Roadmap. Classification of genes.
33. Operon. Lac- and trp-operons. Polycistronic RNA. Regulation of transcription in eukaryotes: preinitiation complex. Enhancers, silencers.
34. Epigenetics: histone modifications, cytosine methylation, CpG-islands,
35. Regulation of gene expression by non-coding RNAs.
36. Methods of nucleic acids isolation.
37. DNA research methods: gel electrophoresis, restriction analysis, nucleic acid hybridization, DNA microarrays. PCR and its types: quantitative PCR, reverse transcription PCR, multiplex PCR. Genome sequencing methods (Sanger sequencing, pyrosequencing, nanopore sequencing, bisulfite sequencing).
38. Genetic engineering: goals, objectives, and stages. Methods for obtaining genes for transgenesis. Recombinant DNA. Construction of vectors, their types.
39. Introduction of recombinant DNA into a recipient cell. Selection of transformed cells. Selective and reporter genes.
40. Biotechnology, its importance for medicine. Genetically modified organisms. Food products containing GMOs.
41. Genetics as a science. Hybridological analysis. Laws of inheritance in a monohybrid cross. Law of purity of gametes. Testcross. Backcrossing.
42. Laws of inheritance in polyhybrid cross. Limitations of Mendel's laws. Pleiotropy.
43. Intraallelic gene interactions (complete and incomplete dominance, superdominance, codominance, and allelic exclusion).
44. Multiple alleles. Inheritance of blood groups in the ABO system. Inheritance of MN blood groups and Rh factor.
45. Interallelic interaction of genes (complementary, inhibitory, polymeric gene action).

46. Bombay blood group as an example of recessive epistasis in humans.
47. Experiments of T. Morgan. Complete and partial genetic linkage. Linkage groups.
48. Chromosomal theory of inheritance. Crossing-over. Genetic and cytological chromosome maps.
49. Sex. Sex-influenced and sex-limited traits. X and Y linked traits.
50. Definition, differentiation, and redefinition of sex in ontogeny. Genetic regulation of gonadogenesis in humans. Peculiarities of sex determination in humans: physical, intermediate and socio-psychological determinants. Disorders of sex development in humans. Ethical and legal aspects of morphological and civil sex changes.
51. X-inactivation. M. Lyon's hypothesis of female mosaicism by sex chromosomes.
52. Variation and its types. Phenotypic plasticity. Combinative variation.
53. Mutations. Causes of mutations: DNA copying errors, unequal crossing over, mutagens.
54. Physical, chemical, and biological mutagenic factors. Genetic hazards of environmental pollution by mutagens. Classifications of mutations. Stability and repair of genetic material. Types of DNA repair. Excision repair, repair of double-stranded breaks. Photoreactivation. Role of repair disorders in human pathology.
55. Carcinogenesis. Oncogenes and tumor suppressor genes.
56. Population. Characteristics of a population. Gene pool.
57. Ideal population. Hardy-Weinberg equilibrium.
58. Factors disturbing Hardy-Weinberg equilibrium: natural selection, genetic drift, mutations, migration, non-random mating.
59. Human genetic polymorphism, its biological, medical, and social aspects. Distinctive features of the human population. Types of marriages. Inbreeding. Mating assortativity. Inbreeding coefficient. Large and small populations. Peculiarities of the gene pool of isolates. Founder and bottleneck effects.
60. Effects of elementary evolutionary factors on human populations.
61. Genetic load, its biological essence, and medical significance.
62. Humans as a specific object of genetic analysis.
63. Methods of human genetics: genealogical analysis, twin study, biochemical tests, molecular-genetic methods.
64. Methods of diagnosing human chromosomal diseases: standard karyotyping, SKY, FISH, and single-nucleotide polymorphism array karyotyping.
65. Rapid diagnostic methods: microbiological tests, detection of X- and Y-sex chromatin, biochemical tests, genetic dermatoglyphics.
66. Neonatal screening of monogenic disorders.
67. Etiology and pathogenesis of human hereditary diseases. Classification of human hereditary diseases.
68. Monogenic and polygenic diseases: disorders of amino acid, carbohydrate, lipid, nucleic acid, mineral metabolism, disorders of blood clotting, and hemoglobin structure.
69. Human chromosome disorders caused by changes in the structure and number of autosomes, full and partial monosomies and trisomies.
70. Mitochondrial diseases.
71. Multifactorial diseases.
72. Principles of treatment of human hereditary pathology.
73. Genetic counseling and its tasks. Indications for directing a family to genetic counseling.
74. Stages of genetic counseling: clinical examination, risk calculation, evaluation of consequences, prognosis.
75. Genetic risk calculation. Laws of addition and multiplication, Bayes' theorem, calculation of posterior probability.
76. Prenatal diagnostic tests for hereditary disorders (alpha-fetoprotein evaluation, ultrasonography, chorionic villus sampling, amniocentesis, cordocentesis, and fetoscopy).
77. Moral and ethical aspects of prenatal diagnosis. Induced termination of pregnancy.
78. Ethical and legal problems of genetic consulting.

Class #15. Topic: **REPRODUCTION OF LIVING MATTER**

CONTENTS OF THE TOPIC

1. Reproduction is a universal property of living things. Forms of asexual reproduction.
2. Forms of sexual reproduction, biological significance. Lateral gene transfer. Hermaphroditism.
3. Ovogenesis and spermatogenesis in humans.
4. Regulation of gametogenesis in humans.
5. Morphological and functional characteristics of mature human gametes.
6. Insemination. Peculiarities of fertilization in humans.
7. Overcoming infertility in humans.
8. Implantation of an embryo, preimplantation diagnosis.

GLOSSARY

1. **Pre-implantation genetic diagnosis –**
2. **Gynogenesis –**
3. **Gamete –**
4. **Insemination –**
5. **Hermaphrodites –**
6. **Asexual reproduction –**
7. **In vitro fertilization –**
8. **Infertility –**
9. **Zona pellucida –**
10. **Spermatogenesis –**
11. **Parthenogenesis –**
12. **Acrosome –**
13. **Lateral gene transfer –**

Task 1. Label the diagrams.

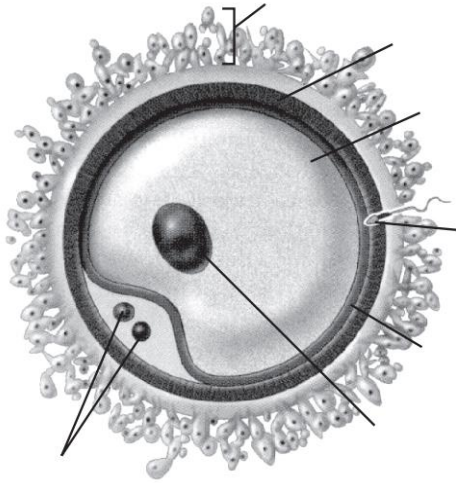

Fig. 1. Diagram of a human egg during fertilization:
1 – polar bodies,
2 – corona radiata,
3 – cytoplasm,
4 – membrane,
5 – zona pellucida,
6 – nucleus,
7 – spermatozoon

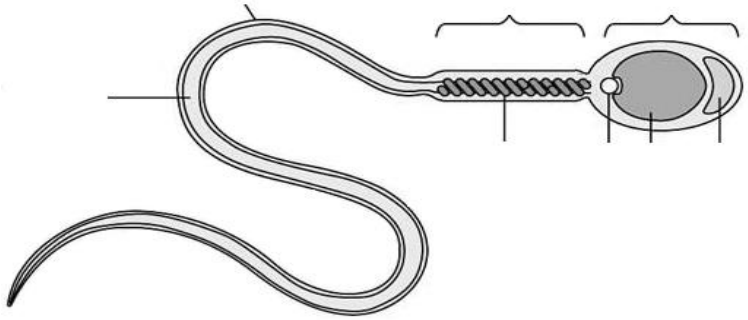

Fig. 2. Diagram of human sperm:
1 – head, 2 – middle piece,
3 – membrane, 4 – acrosome,
5 – nucleus, 6 – mitochondria,
7 – flagellum, 8 – centrosome

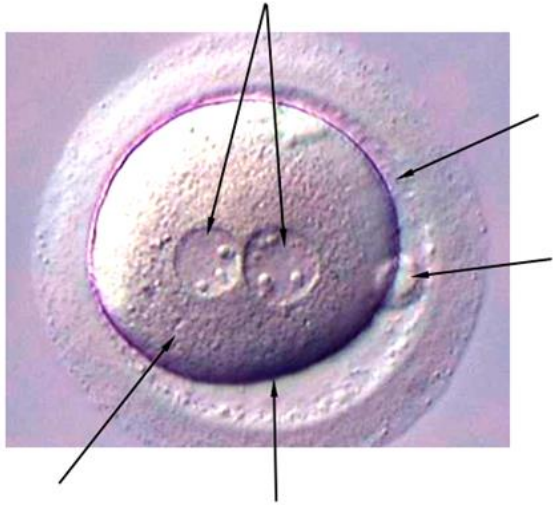

Fig. 3. Zygote of human:
1 – polar body,
2 – zona pellucida,
3 – pronuclei,
4 – membrane,
5 – cytoplasm

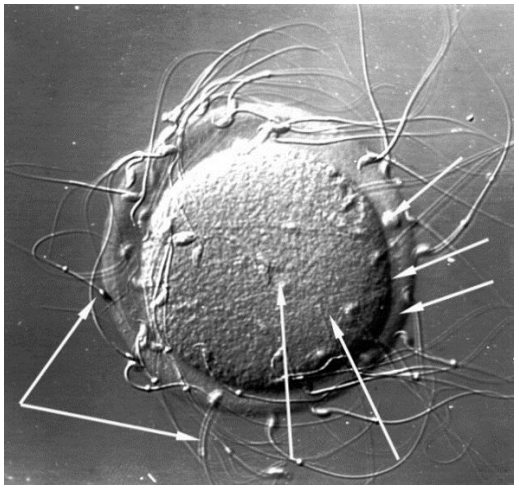

Fig. 4. Fertilization of the mouse egg cell in vitro:
1 – polar body,
2 – zona pellucida,
3 – pronucleus,
4 – membrane,
5 – cytoplasm,
6 – spermatozoa

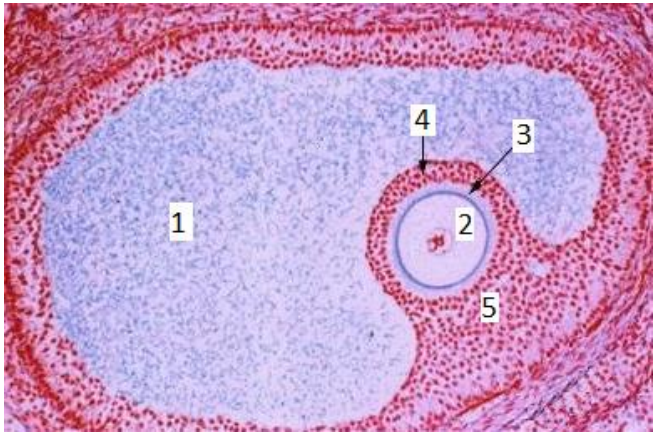

Fig. 5. Graafian follicle:
– secondary ovocyte,
– cumulus oophorus,
– corona radiata,
– follicular cavity,
– zona pellucida

Task 2. Solve the problems.

Problem #1. In the case of parthenogenesis unfertilized ovum gives rise to a new organism. Why can't a spermatozoon do the same?

Problem #2. Planarians can multiply asexually and sexually by self-fertilization. Is the genotype of the progeny produced by self-fertilization the same as that of the progeny produced by asexual reproduction? Explain your answer?

Problem #3. Semen analysis of persons A and B revealed that their spermatozoa have normal morphology, but the spermatozoa of A are immovable and the spermatozoa of B stay on the surface of the egg cell and do not pass inside. What structures of sperms may not perform their normal functions in these cases?

Problem #4. Autopsy of 22-year-old dead women revealed that her ovaries contained:

Left ovary (smaller)	Right ovary (bigger)
17 000 follicles	25 000 follicles
26 corpora albicantia	48 corpora albicantia

Almost all follicles are very small though 339 of them were larger than 100 μm. If one follicle forms one corpus luteum, then:
a) at what approximate age did ovulations begin in this woman?
b) until what age could this woman have continued to ovulate?

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Class #16. Topic: **FUNDAMENTALS OF PRENATAL ONTOGENESIS**

CONTENTS OF THE TOPIC

1. Ontogenesis. Periodization of prenatal ontogenesis.
2. Prezygotic period. Prenatal period: zygote, cleavage, gastrulation, histogenesis, and organogenesis.
3. Extraembryonic membranes of chordates.
4. Regulation of embryonic development.
5. Critical periods of human intrauterine development, teratogenic factors.
6. Genomic imprinting. Diseases of genomic imprinting.
7. Periods of postnatal ontogenesis.
8. Growth and development of the human body and its regulation. Acceleration.
9. Human constitution and habitus, their medical significance.
10. Critical periods of postnatal ontogenesis.
11. Biological aspects of ageing. The concepts of gerontology, geriatrics, and valeology. Molecular and genetic aspects of aging.
12. Clinical and biological death. Resuscitation and its biological aspects. Moral and ethical problems of euthanasia.

GLOSSARY

1. **Ontogenesis –**
2. **Blastomere –**
3. **Cleavage –**
4. **Teratology –**
5. **Gastrulation –**
6. **Germ layers –**
7. **Blastocyst –**
8. **Ageing –**
9. **Clinical death –**
10. **Telomeres –**
11. **Valeology –**

Task 1. Label the diagrams.

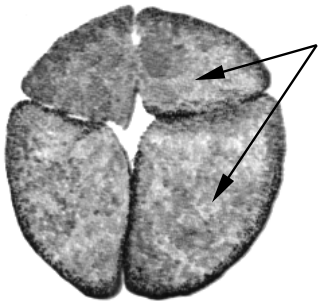

Fig. 1. Cleavage of frog's zygote:
1 – blastomeres

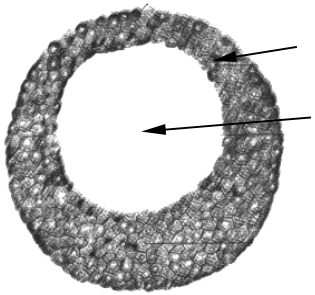

Fig. 2. Blastula of frog:
1 – blastomeres, 2 – blastocoel

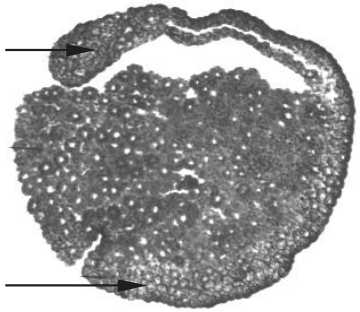

Fig. 3. Gastrula of frog:
1 – dorsal lip of blastopore,
2 – ventral lip of blastopore

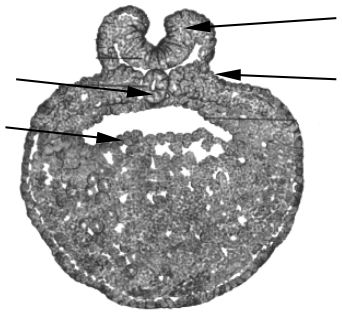

Fig. 4. Neurula of frog (7x8):
1 – ectoderm, 2 – neural fold,
3 – notochord, 4 – endoderm

Task 2. Match the type of growth in the left column with corresponding tissues, organs, or body parts in the right column.

A. General	1. Liver
	2. Brain
	3. Spleen
B. Cerebral	4. Fallopian tubes
	5. Prostate
	6. Tonsils
C. Lymphoid	7. Eyes
	8. Skeleton
	9. Thymus
D. Reproductive	10. Spinal cord
	11. Ovaries
	12. Muscles

A			B			C			D		

Task 3. Match the phenomenon in the left column with a hallmark of ageing in the right column.

1. Aging-associated accumulation of point mutations, translocations, chromosomal gains, losses, etc	A. Mitochondrial Dysfunction
2. Shortening of terminal regions of chromosomes explains limited ability for division	B. Epigenetic Alterations
3. Anabolic signaling is associated with ageing	C. Telomere Attrition
4. Alterations in DNA methylation patterns, modifications of histones, chromatin remodeling	D. Altered Intercellular Communication
5. Changes in biogenesis, folding, trafficking, and degradation of proteins	E. Stem Cell Exhaustion
6. Alterations in the normal function of mitochondria	F, Genomic Instability
7. Phenomenon characterized by the cessation of cell division	G. Loss of Proteostasis
8. Decrease in the number of undifferentiated cells able to produce new specialized cells	H. Deregulated Nutrient-sensing
9. Changes in signals transmitted from cell to cell	I. Cellular Senescence

1	2	3	4	5	6	7	8	9

Task 4. Match the germ layer in the left column with the tissues they produce in the right column.

A. Ectoderm	1. Brain
	2. Epidermis
	3. Epithelial lining of the pancreas
B. Mesoerm	4. Bones
	5. Epithelial lining of the bronchial tree
	6. Dermis
C. Endoderm	7. Blood vessels
	8. Epithelial lining of the small intestine
	9. Pituitary gland

A			B			C		

Task 5. Match the concepts in the left column with their names in the right column.

1. Participates in the feeding of the embryo; the first hematopoietic organ	A. Yolk sac
2. The outgrowth of the posterior region of the gut, participates in the formation of the placenta in mammals	B. Amnion
3. A sac with fluid that forms an aquatic environment for the embryo and fetus, protects it from drying out and injury	C. Chorion
4. External covering contacting with the mother's tissues; participates in formation of placenta	D. Allantois

1	2	3	4

Task 6. Match the concepts in the left column with their names in the right column.

1. The process in which one group of cells, the inducing tissue, directs the development of another group of cells	A. Positional information of the cell
2. Signaling molecule that acts over long distances to induce responses in cells based on the concentration of these molecules	B. Morphogenesis
3. The coordinate system associated with concentration gradients of signaling molecules	C. Induction
4. The process by which a cell or group of cells becomes specialized in structure and function	D. Morphogen
5. The developmental process by which tissues and organs acquire the shape that is critical to their function	E. Differentiation

1	2	3	4	5

Task 7. The twinned tadpole of the frog shown was made in an experiment demonstrating embryonic induction. How such an experiment can be conducted?

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Class #17. Topic: **GENERAL PARASITOLOGY**

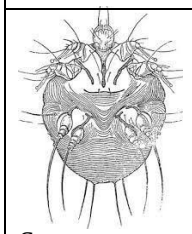
CONTENTS OF THE TOPIC

1. Parasitism. Criteria for parasitism. Medical parasitology, its goals and objectives.
2. Parasite-host system. Parasitic system.
3. Classification of parasites and their hosts.
4. Transmission routes of parasites.
5. Pathogenic action and specificity of parasites.
6. Morphophysiological and biological adaptations of parasites.
7. Response of the host organism to the introduction of parasites.
8. Classification of parasitic diseases.

GLOSSARY

1. **Symbiosis –**
2. **Parasite –**
3. **Host of a parasite –**
4. **Ectoparasite –**
5. **Temporary parasite –**
6. **Obligate parasite –**
7. **Molecular mimicry –**
8. **Definitive host –**
9. **Intermediate host –**
10. **Transmission route of a parasite –**
11. **Biological vector –**
12. **Pathogenicity –**
13. **Host specificity –**

Task 1. Classify the parasites.

Parasite	Description	According to interaction with the host:	According to location in the host:	According to duration of interaction with the host:
 *Sarcoptes scabiei*	Permanently resides in the outer layer of the skin. Infection occurs through direct contact with patients or their bed-linen, etc			
 Head louse	Spends its entire life on the human scalp and feeds exclusively on human blood			
 Ascaris lumbricoides	Infection occurs by ingestion of eggs. Alternation of life stages occurs in the host's body			
 Ixodid tick	Lives by feeding on the blood. Contact with the host lasts from several hours to several days			

Task 2. Study the life cycle of the tapeworm. Classify the hosts of this parasite according to its life cycle stage.

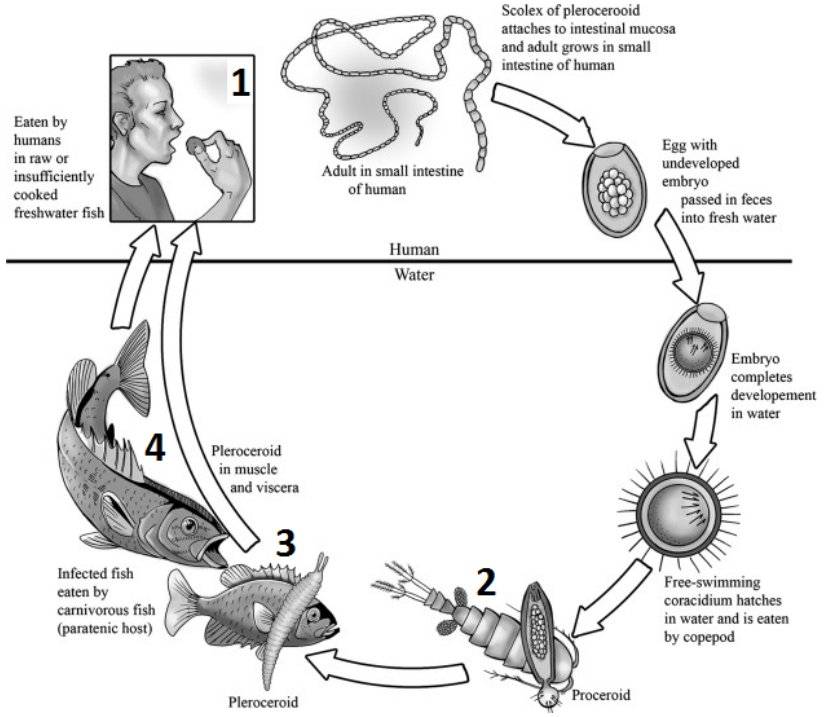
Fertilized eggs of the parasite are excreted from the **human body (1)** with feces. In the water, a larva (coracidium) hatches from the egg and is swallowed by a **freshwater crustacean (2).**

The next larval stage (procercoid) is formed in the crustacean's gut.

When the crustacean is swallowed by **a small fish (3)**, the procercoid becomes a plerocercoid in its muscles and genital organs.

Predatory fish (4) can eat the affected fish, accumulating plerocercoids.

Infection of **humans (1)** occurs when small or big fish are eaten.



Which hosts are the organisms with the numbers?

1 –

2 –

3 –

4 –

Task 3. Match the transmission route of the parasite in the left column with its name in the right column.

1. Pathogens pass from the pregnant woman to the fetus during the period of intrauterine development	A. Contact
2. Pathogens are localized on the mucosa of the respiratory tract and pass to the susceptible organism through the air	B. Contact with infected blood
3. Pathogens are localized on the skin or the mucous membranes, from where they can get on the surface of various objects, and contact with them infects the susceptible organism	C. Vertical
4. Transmission of pathogens is mediated by vectors, which are usually blood-sucking arthropods	D. Respiratory
5. Pathogens are mainly localized in the gastrointestinal tract and pass from the infected organism with feces	E. Fecal-oral
6. Pathogens circulate in the blood and pass into the susceptible organism through contact with the blood of an infected person	F. Vector-borne

1	2	3	4	5	6

Task 4. Fill in the table: «Adaptations to parasitism»

Progressive morphological and physiological adaptations of parasites:
Regressive morphological and physiological adaptations of parasites:

Biological adaptations of parasites:

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Class #18. Topic: **PARASITES OF HUMAN (I)**

CONTENTS OF THE TOPIC

1. General characteristics of the kingdom Protista.
2. Life cycle of malaria pathogens (*Plasmodium spp*.). Species of plasmodia and their morphological characteristics in a thin blood smear. The symptoms, and diagnosis of malaria. Prevention of malaria.
3. *Toxoplasma gondii*: morphology, life cycle, routes of transmission, pathogenic action. Diagnosis and prevention of toxoplasmosis.
4. *Entamoeba histolytica*. Morphology, life cycle, routes of transmission, pathogenic action. Symptoms, diagnosis, and prevention of amebiasis. Entamoeba gingivalis.
5. *Trichomonas vaginalis*: morphology, life cycle, routes of transmission, pathogenic action. Symptoms, diagnosis, and prevention of the diseases caused by the parasite.

GLOSSARY

1. **Trophozoite –**
2. **Cyst –**
3. **Exoerythrocytic cycle –**
4. **Schizont –**
5. **Hypnozoites –**
6. **Sporozoite –**
7. **Merozoite –**
8. **Sporogony –**
9. **Schizogony –**
10. **Congenital toxoplasmosis –**
11. **Oocyst –**
12. **Tissue cyst –**

Task 1. Label the diagrams.

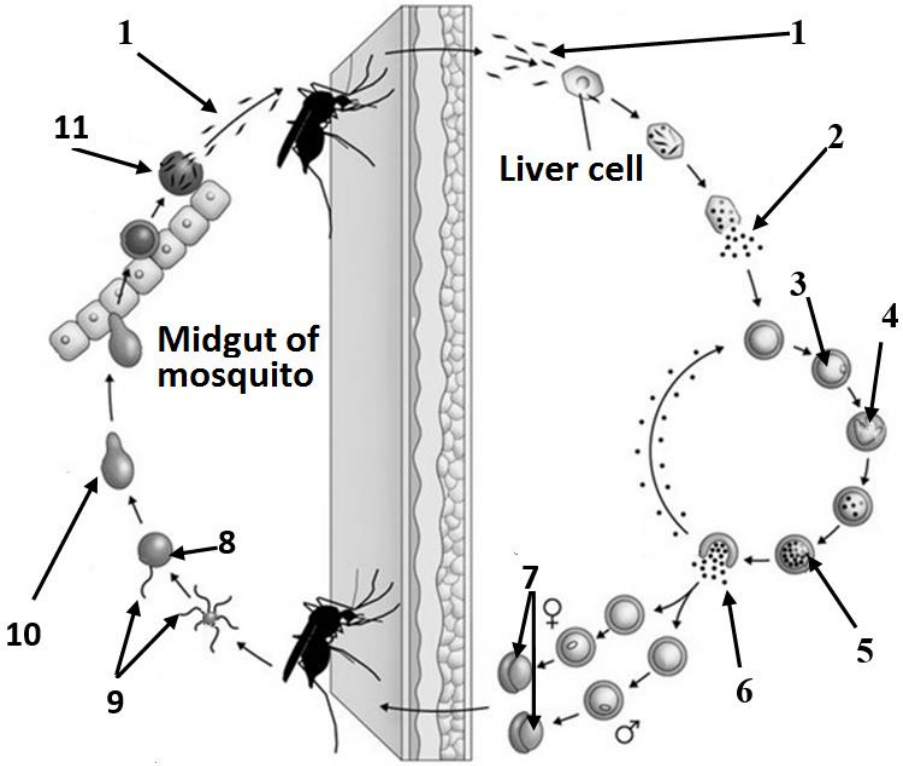


Fig. 1. Plasmodium life cycle

1.	7.
2.	8.
3.	9.
4.	10.
5.	11.
6.	

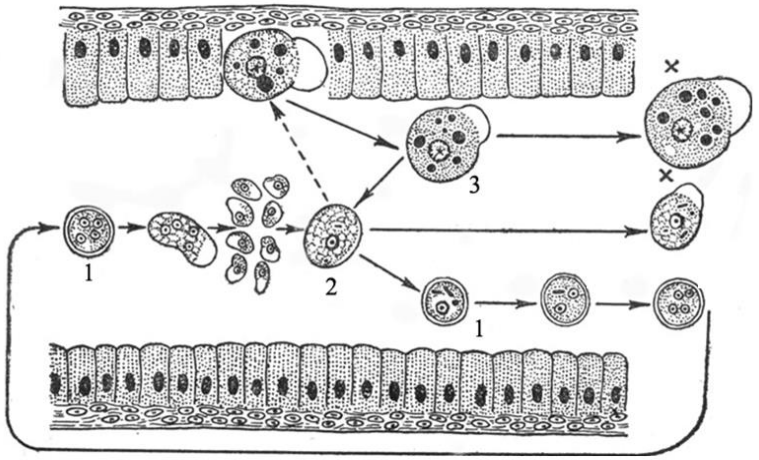


Fig. 2. The life cycle of *Entamoeba histolytica:*

1 –

2 –

3 –

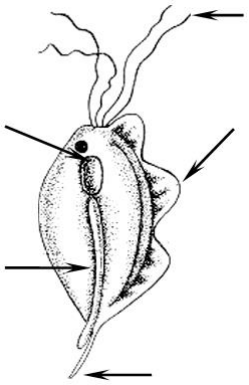
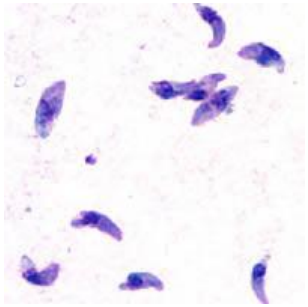
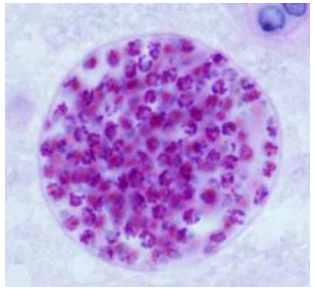


Fig. 3. Trichomonas vaginalis:
1 – nucleus, 2 – undulating membrane,
3 – flagella, 4 – axostyle, 5 – spine

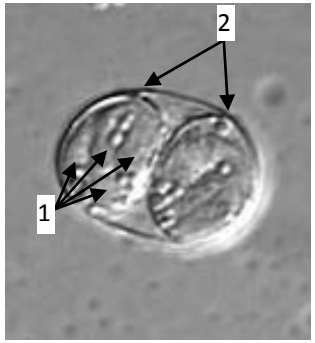
Task 2. Identify the parasite. Label the diagrams.



A



B



C

The Latin name of the parasite:

_____

A –

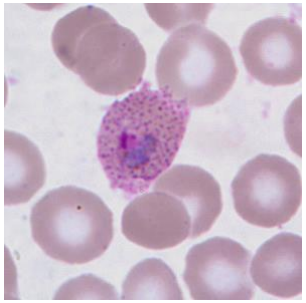
B –

C –

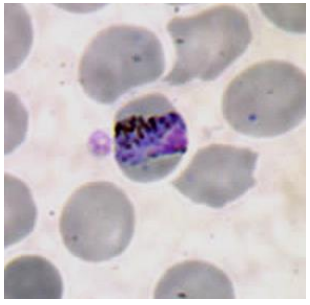
1 –

2 –

Task 3. What are the species of the parasites from the pictures?



1



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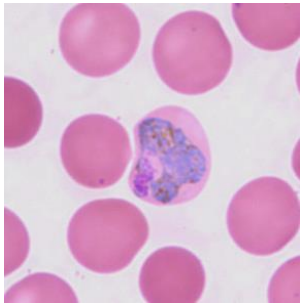

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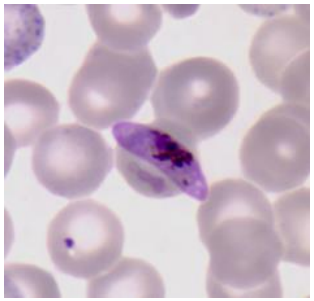

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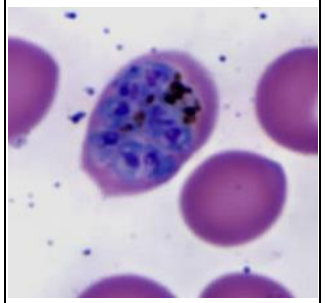

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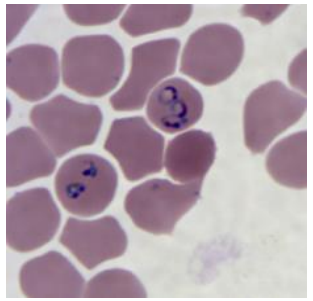

6

Schizont of *Plasmodium ovale* –

Gametocyte of *Plasmodium falciparum* –

Trophozoite of *Plasmodium ovale* –

Band-form trophozoite *Plasmodium malariae* –

Ring-form trophozoite *Plasmodium falciparum* –

Amoeboid-form trophozoite of *Plasmodium vivax* –

Task 4. Make a diagnosis in the following cases.

Case #1. A patient was hospitalized with complaints of fever, headache and muscle ache, weakness. The patient said that the disease began 4 days ago. The first symptoms were chill which changed to a fever of 40°C in two hours. In several hours, the temperature lowered to 35°C, and profuse sweating occurred. The patient recently came back from a business trip in Africa. What disease should be supposed?

Case #2. Unicellular parasites 4-7 × 2-4 μm in size were found in the cerebrospinal fluid of the patient. Cells were crescent-shaped, one end of the cell is tapered, and the other one is rounded. Identify the parasite.

Case #3. Peripheral blood of the patient has red blood cells with ring-shaped trophozoites, multiply infected cells are common. There are crescent-shaped gametocytes. Schizonts contain from 12 to 24 nuclei. Identify the parasite.

Case #4. A case of miscarriage happened in a 22-year-old woman in the 5th month of pregnancy. Histological tests of the placenta, fetal membranes, and organs of the fetus revealed aggregations of protists of crescent shape 4-7 micrometers in size. The nucleus is clearly stained in red and the cytoplasm in blue color. The woman likes animals and has two cats and a guinea pig. What disease should be supposed?

Case #5. Four-nucleated round cysts 8–16 μm in diameter were found in the stool test of a kindergartner. What parasite do the cysts belong to? Is it possible to admit the kindergartner to work?

Case #6. A woman sought medical help from a doctor with complaints of itching, burning, redness of the genitals, and yellowish foul-smelling vaginal discharge. A native smear prepared from freshly collected secretions revealed mobile pear-shaped protists, 15-30 microns in size, 4 flagella, and an undulating membrane at the anterior end. What parasitic disease can be supposed?

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Class #19. Topic: **PARASITES OF HUMAN (II)**

CONTENTS OF THE TOPIC

1. General characteristics and classification of flatworms. *Opisthorchis felineus* and *Taenia solium*: morphology, life cycle, routes of transmission, pathogenic action. Symptoms, diagnosis, and prevention of opisthorchiasis, taeniasis, and cysticercosis.
2. General characteristics and classification of nematodes. *Ascaris lumbricoide*s and *Enterobius vermicularis*: morphology, life cycle, routes of transmission, pathogenic action. Symptoms, diagnosis, and prevention of ascariasis and enterobiasis.
3. General characteristics and classification of arthropods. *Sarcoptes scabiei*: morphology, life cycle, routes of transmission, pathogenic action. Symptoms, diagnosis, and prevention of scabies.
4. *Pediculus humanus* and *Pthirus pubis*: morphology, life cycle, routes of transmission, pathogenic action, medical significance. Symptoms, diagnosis, and prevention of pediculosis capitis, pediculosis corporis, and pthiriasis.

GLOSSARY

1. Esophageal bulb –

2. Cephalic alae –

3. Geohelminths –

4. Metacercaria –

5. Miracidium –

6. Strobila –

7. Oncosphere –

8. Nymph –

9. Imago –

10. Scolex –

11. Proglottid –

Task 1. Label the diagrams.

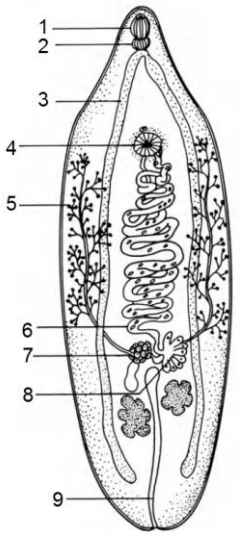


Fig. 1. Opisthorchis felineus:

1 –
2 –
3 –
4 –
5 –
6 –
7 –
8 –
9 –
10 –

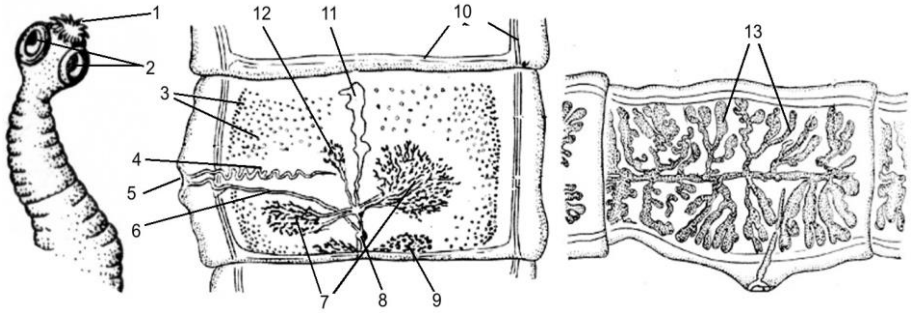
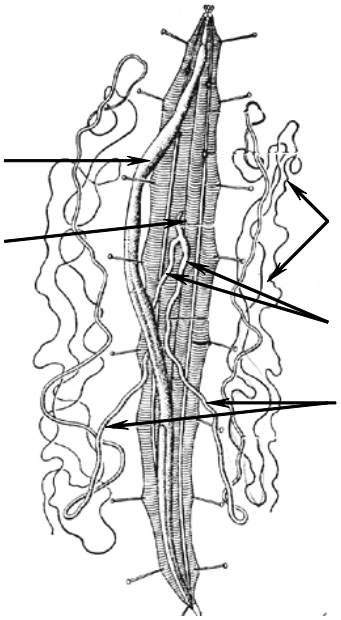


Fig. 2. Scolex, mature and gravid proglottids *Taenia solium:*

1 –
2 –
3 –
4 –
5 –
6 –
7 –
8 –
9 –
10 –
11, 13 –
12 –

Fig. 3. Dissected *Ascaris lumbricoides:*

1 – ovaries,
2 – oviducts,
3 – uteri,
4 – vagina,
5 – intestine



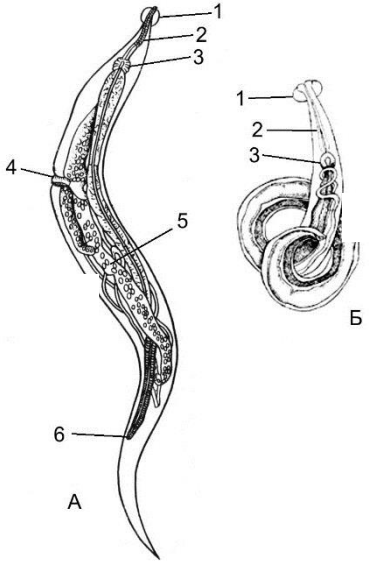
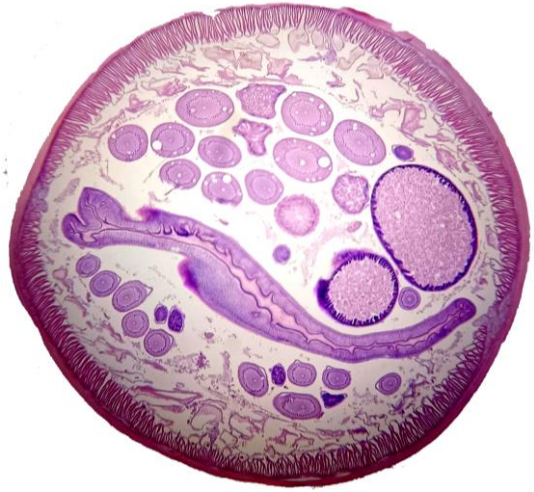
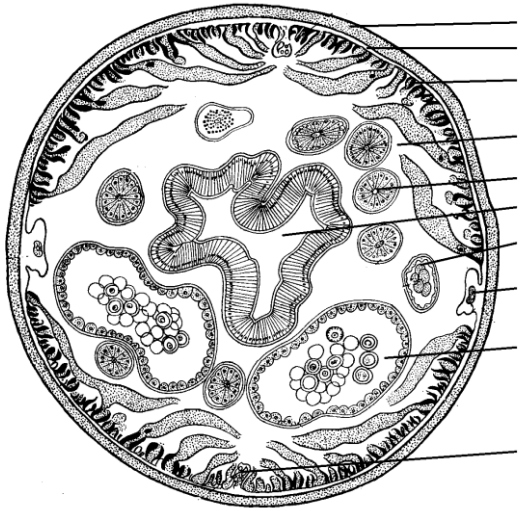


Fig. 4. Female and male *Enterobius vermicularis:*

1 –
2 –
3 –
4 –
5 –
6 –



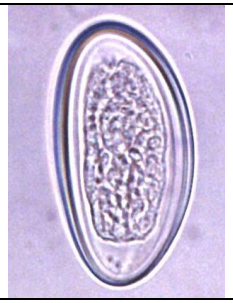
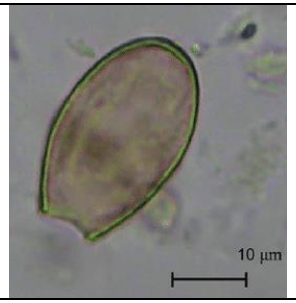
A



B

Fig. 5. Cross-section of *Ascaris lumbricoides:*
A – photograph; B – diagram:
1 – cuticle, 2 – hypodermis, 3 – muscle cells, 4 – body cavity, 5 – canal of the excretory system, 6 – nerves, 7 – lumen of the intestine, 8 – ovaries, 9 – oviducts, 10 – uteri

Task 2. Identify the parasites and write their Latin names.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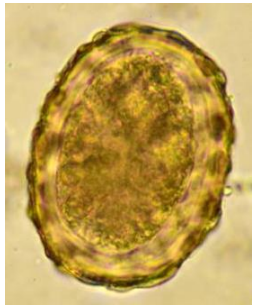
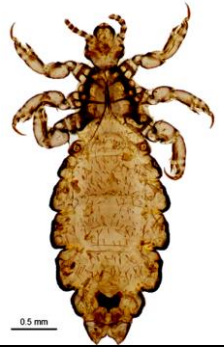
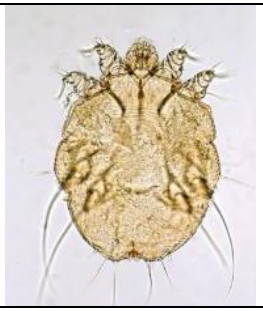
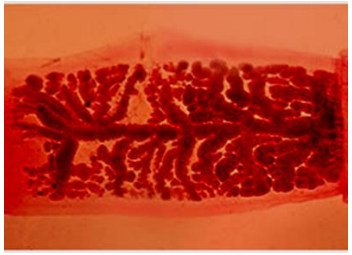
		
4.	5.	6.
		
7.	8.	9.

Task 3. Make a diagnosis in the following cases.

Case #1. During endoscopic examination of the duodenum, a small yellowish helminth measuring 1 cm in length was found. What is the species of the parasite?

Case #2. A 45-year-old patient was admitted to a neurological department of a hospital complaining of frequent headaches and seizures. 5 years ago the patient had taeniasis. What parasitic disease can be supposed?

Case #3. Proglottids of a tapeworm were delivered to the laboratory. Microscopy reveals 7 to 12 lateral branches of the uterus on each side. Identify the parasite.



Case #4. A 40-year-old man with symptoms of intestinal obstruction was hospitalized. During surgery, 9 white-pink worms, 22-38 cm long were found in the intestine. Identify the parasite.

Case #5. A woman found white helminths in the pants of her child and delivered them to the laboratory. The helminths are up to 1 cm long. Identify the parasite.

Case #6. During the regular medical examination of kindergarten staff, eggs were found in stool samples of one of the kindergarteners. The eggs were 50-60 × 26-30 μm in size, colorless, oval, and slightly flattened on one side. What disease should be supposed?

Case #7. A patient has itching between the fingers, wrists, and lower part of the abdomen. The affected area has a pimple-like skin rash. What parasitic disease can be supposed?

Case #8. A 9-year-old boy complains of severe itching in the scalp. Examination of his head revealed coarsening and pigmentation of the skin. What disease should the boy be tested for?

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